Serfojee Rajah 1807

ELEMENTS

OF

MINERALOGY

1381

BY

1381

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PREFACE.

1381

WHEN we conſider the degree of excellence which many of the practical arts buſied in the treatment of Minerals have reached in *England*, and alſo that in the merely ſpeculative ſciences, we are at leaſt on a level with our neighbours on the continent, it cannot but be matter of ſurprize that, with reſpect to Mineralogy, the parent of theſe arts, they ſhould ſtand confeſſedly ſuperior to us. That this inferiority on our ſide does not originate in any want of ingenuity in our artiſts evidently appears by the maſterly productions of a *Parker* and a *Wedgewood*. The true cauſe lies deeper. Mineralogy is an art, whoſe cultivation and improvement requires both ſpeculation and practice: the mere theoriſt will never deſcend into the laborious details of the practical part, without due encouragement or a degree of enthuſiaſm, in a country devoted to politics rarely to be met with, and the practical artiſt ſeldom poſſeſſes thoſe general principles of ſcience and extenſive acquaintance with the diſcoveries of his cotemporaries that are indiſpenſably requiſite to eſtabliſh him on a footing of equality with them. On the continent Mineralogy is on a very different footing. In *Sweden* and *Germany* it is conſidered as a branch of ſcience worthy of the atten-

tion of government. There are colleges in which it is regularly taught; it forms a diſtinct and honourable profeſſion, like that of the ſoldier, the merchant, or the barriſter; its ſuperior officers form a part of the adminiſtration of the ſtate. Young ſtudents, fraught with the knowledge to be acquired in their own country, are ſent abroad to glean all that can be collected from a more diverſified view of nature, or a more improved practice of the arts. This example has been lately followed by the *French*, the *Ruſſians*, and even the *Spaniards*.

The French have erected a Mineralogical School at *Paris*, to which a conſiderable penſion is annexed. Subterraneous maps of the whole kingdom are now a tracing, and mineralogical voyages are from time to time undertaken at the public expence *. Chymiſtry, the Parent of Mineralogy, is cultivated by the moſt enlightened nations in *Europe*, and particularly in *France* with a degree of ardour that approaches to enthuſiaſm; it forms the favourite occupation, and even the moſt faſhionable object of attention not only of the middling, but even of ſome in the higheſt ranks of ſociety †.

In

* As that of Mr. *Jars*, &c.

† Among theſe we may reckon in *Ruſſia* prince *Gallitzen*; in *Germany* count *Sickengen*; in *Italy* the counts *de Saluces* de

In *England*, on the contrary, (a country far richer than *France* in mineral productions) it receives no encouragement from the public, and few apply to it except gentlemen in the Medical Line, whose transient attention is soon diverted by their more direct occupations. The consequences are obvious. The grossest blunders are daily committed in working our mines and extracting our ores; insomuch, that learned foreigners have remarked that were it not for their superior excellence, and the cheapness of fuel, their extraction would infallibly be attended with loss †, and many useful substances are daily rejected as useless.

Sensible of our inferiority in this respect, and well acquainted with the cause of it, the zealous and learned Doctor *Shaw*, and our late eminent Chymist Dr. *Lewis*, have laboured to promote and facilitate the study of Chymistry among us, and for this purpose transfered into our own language the most considerable improvements made in their time

de Morozzo, and the marquis *de Gironi*, governor of *Leghorn*; in *Geneva* Mr. *de Saussure*; in *France* the dukes *de Chaulnes*, *Rochefoucault*, and *D'Ayen*; the counts *de Lauragais*, *la Garay*, *Milly*, *Tressan*, and *de la Tour d'Auvergne*; the marquisses *de Courtenvaux* and *de Courtivron*; the barons *d'Olbach* and *de Servieres*; madame *la Presidente d'Arconville*; messieurs *Trudaine*, *Lavoisier*, *Montigny*, and above all, Mr. *de Morveau*, one of the first chymists of the age.

† *Ferber*, *Reise Derbyshire*.

 by

by foreigners. At a still later period Mr. *Keir* has poured upon us many valuable treasures in his excellent notes on Mr. *Maquer*'s Chymical Dictionary, a work generally known, and equally esteemed; yet since this work appeared, (the last of any note among us) such rapid advances have been made in the mineralogical art in particular, that it has put on quite a new face. Several new semi metals have been discovered, the number of primitive earths ascertained, many analyses accomplished heretofore attempted in vain, and the art itself of Mineral Analysis brought to a degree of certainty and precision of which it was scarcely thought capable. Actuated by the same views as the patriotic gentlemen just mentioned, I have endeavoured to collect in the ensuing treatise all that has been hitherto done in this science, with some few improvements of my own, modelled and digested in the method that seemed to me most useful.

The point which I principally laboured was not to present the reader with a minute detail of the various external appearances of minerals in various countries, nor of their situation, vicinity, or mixture with each other, circumstances ever contingent and fortuitous, much less to entertain him with prolix and plausible accounts of their origin, enquiries

enquires which appear to me to belong to another branch of the ſcience of foſſils, viz. *Natural Hiſtory*, but rather to determine the characters by which foſſils are invariably and permanently diſtinguiſhed from each other in all times and places. In a word, rather to define the *ſpecies* than deſcribe the *individual*; even among theſe permanent characters I have, for the ſake of brevity, omitted all, except the moſt obvious, a compleat detail of them being in my opinion fitter for a treatiſe of Chymiſtry than of Mineralogy. The merit of this latter ſeeming to me to conſiſt in preſenting ſuch *criteria* as may enable us to diſtinguiſh Minerals in the ſhorteſt, eaſieſt, and ſureſt manner; ſo that we may always apply the ſame names to the ſame ſubſtances, and being confident of ſpeaking the ſame language, may always underſtand each other. What confuſion hath heretofore ariſen from the ambiguity of names is well known, and will, I fear, render many very intereſting reſearches, even of modern date, intirely uſeleſs. Among theſe I ſhall only mention thoſe of the celebrated *Canon Recupero*, who for many years, and with immenſe pains, has ſtudied and deſcribed the Minerals in the neighbourhood of *Mount Ætna*, but committed ſuch miſtakes in their denomination as will, according to the remark of that excellent Mineralogiſt

Mr. *Saussure*, render his work, if ever it appears, absolutely unintelligible *.

Whether the characters of Minerals should be taken from external appearances only, or from their internal properties as discovered by chymical agents, has long been controverted among Mineralogists; though, indeed, at present the controversy seems almost at an end from the universal approbation with which the system of the celebrated *Cronsted*, founded almost entirely on chymical characters as far as they were known in his time, has been received by all *Europe*. However, some able patrons of the former opinion have appeared of late, among whom I shall mention only Mr. *Werner* and Mr. *Romé de Lisle*.

Mr. *Werner* is the author of an excellent treatise written in the *German* language on the external characters of fossils. Mr. *Romé* has lately published a voluminous treatise on the external forms of crystals, under which title he comprehends all those fossils that are susceptible of a regular figure, all of which he pretends may be distinguished by the angles which their planes make with each other, *if some heterogeneous matter be not contained in them*; but supposing all this to

* *Voyages des Alps*, p. 67.

be

be true, what a vaſt variety of figures are not theſe cryſtals ſubject to from a variety of accidents? How many indeterminate and confuſed cryſtallizations reducible to no certain figure? By how many external accidents may not theſe figures, though originally perfect, be altered and modified? What ſhall we ſay of his *macles* or agglutinated cryſtals? of the conic, ſpheroidal, cilyndrical ſhapes in which no angle can be diſcovered? and of the various amorphous appearances of moſt Minerals?

Mr. *Werner* has endeavoured to claſſify Minerals by the joint conſideration of all their external properties, and yet, that even this re-union is inſufficient to determine their nature, he himſelf gives us a clear proof in his notes on *Cronſted*, p. 217. There, on the faith of theſe characters, he ranges among *micas* a green foliated ſubſtance, which, being ſent to Mr. *Bergman*, proved to be a compound of marine ſalt of copper and argillaceous earth, though the quantity ſent him amounted but to one grain; ſo much ſurer are chymical teſts! Every ſcience muſt be founded on permanent principles. The only principles of this ſort that Mineralogy affords are the relations of the bodies it conſiders with chymical agents. Without referring to theſe, it can be reckoned at moſt only a conjectural

jectural art. This will plainly appear by examining each of the external characters in particular; namely, colour, tranſparency, or opacity, coherence, texture, ſhape, and ſpecific gravity.

And firſt as to *colour*, Mr. *Werner* ownes that white quartz, white lead ore, and white calcareous iron ore, have exactly the ſame *ſnow white* colour. Some ſpecies of the ores of iron, manganeſe, cobalt, and copper, the ſame *iron grey* colour, wolfram and blende the ſame *browniſh black*, &c. in ſhort it is well known, that the ſlighteſt change in the texture of bodies, frequently produces a conſiderable alteration in colour; thus a lump of cinnabar, whoſe colour is *dark red*, becomes of a beautiful *florid red*, by ſimply reducing it to a powder; beſides it is difficult, if not impoſſible, to render the various ſhades of colour intelligible by any deſcription.

Tranſparency and Opacity are qualities common to a vaſt variety of ſubſtances, different in all other reſpects. They are ſuſceptible of numerous undiſcribable degrees, and diſcover at moſt the mode of union, not the ſubſtances united.

Coherence and hardneſs are properties equally ambiguous: with reſpect to earths and powdered

dered ſtones, their conſideration is of no uſe, ſtriking fire with ſteel, has often been given as a teſt of pure ſiliceous earths, but it is now known, that well baked clay, to ſay nothing of other compound ſubſtances, will exhibit the ſame appearance.

Texture, all its varieties as granular, lamellar, fibrous, ſcaly, equable, &c. are common to ſubſtances, widely different; thus the fibrous is found in ſome varieties of gypſum, in aſbeſtos, ſhoerl, pumice, pyrites, antimony, hæmatites, malachite, cobalt, and arſenical ores, the ſcaly in lead and iron ores, mica, limeſtones, gypſum, the lamellar, granular, and equable, are ſtill of wider extent.

Shape, the varieties of this even when regular and determinate, are endleſs, as may be ſeen in Mr. *De Liſle's* Treatiſe, and muſt be ſo, as they depend of various external accidents, thus he finds 32 varieties in the ſhape of calcareous ſpar, 14 in that of gypſum, 9 in that of fluor, 16 in that of quartz, beſides its *monſtrous* forms, equally regular as the reſt, 19 in that of felt ſpar, &c. and not only the ſame ſpecific ſubſtance is ſuſceptible of various ſhapes, but various ſubſtances ſpecifically different, aſſume the ſame ſhape. Thus the native calx of arſenic, blende, cinnabar, and grey copper ore, often appear in a tetrahædral form;

form; common ſalt, fluor, zeolyte, galena, in a cubic, &c. if the nature of any ſubſtance could be determined by its form, it would undoubtedly be that of ſalts, yet there is ſcarce any of theſe which in different circumſtances, may not aſſume a different figure; Mr. *Pott* aſſures us, that microcoſmic ſalt aſſumes the figure of almoſt all other ſalts, nitre, vitriol, ſalammoniac, allum, glauber's ſalts, &c. 4 *Pott*, 49. According to *Maquer*, if ſublimate corroſive be cryſtalized, by cooling it forms needles, but if by mere evaporation, cubes or lozenges. *Mem. Par.* 1755, p. 540. Digeſtive ſalt will form cubes if it be exactly neutral, but if the alkali predominates quadrangular priſms, common ſalt is generally looked upon as the moſt conſtant in its figure, yet Mr. *Cadet* has found it cryſtalized in needles, 9 *Mem. Scav. Etrang.* p. 555. and *Gerhard*, 4 *Berlin, Schrift.* 292. Very many, if not moſt of the miſtakes to be found in chymical writers on ſalts, aroſe from their having denominated them from their figure.

Laſtly, *Specific Gravity*, which is certainly one of the beſt external teſts, frequently varies, by reaſon either of the different texture of the ſame ſpecies of mineral, into whoſe interſtices water cannot equally penetrate, or by reaſon of the greater proportion of ſome

or

or other of the conſtituent parts, as is particularly obſervable in zeolytes, which differ exceedingly in the proportion of water which enters into them as one of their conſtituent principles: alſo in the ſparry or calcareous iron ore, whoſe proportion of calcareous earth is ſubject to great variation; beſides all this, various ſubſtances ſpecifically different, poſſeſs very nearly the ſame ſpecific gravity.

Nevertheleſs I am far from aſſerting, that the conſideration of mere external properties is intirely uſeleſs; on the contrary, I am perſuaded that from the conſideration of theſe alone, a very probable conjecture may be drawn in moſt caſes concerning the nature of foſſils, whoſe ſpecific properties are already known by analyſis, but this conjecture muſt be formed by an experienced eye: for it is not poſſible by any deſcription, to convey an adequate idea of thoſe minute differences, or as I may ſay, the *phyſiognomies* of foſſils, by which alone they are diſtinguiſhable. On this account I have been very ſuccinct in this particular, rather hoping to help, than expecting to form the *coup d'œil*. Thoſe who love to amuſe themſelves with a detailed deſcription of theſe external forms, may conſult with advantage Mr. *Romé de Liſle's* improved edition of his *Cryſtallographie* *, though daily expe-

* Or the improved edition of *Cronſted*, which Mr. *Magellan* promiſes ſoon to publiſh.

rience evinces, that nature is ſtill more varied than his deſcriptions.* But where any *new* ſubſtance occurs, or an intire certainty required, ſuch as conſtitutes the foundation of a *ſcience*, there chymical teſts are abſolutely requiſite, and alone ſufficient. Thus neglecting theſe, Mr. *Romé de Liſle* took that to be a zeolyte which Mr. *Pelletier* afterwards found to be an ore of zinc. 2 *Cryſtallogr.* p. 46, 20 *Roz.* 424.

Mineralogy muſt therefore, on the whole, be conſidered as a branch of Chymiſtry, and its progreſs, like that of other branches of that ſcience, has been for many ages ſcarce ſenſible. In the earlieſt times, of which we have any account in hiſtory, mankind ſeem to have been of the ſame turn of thinking as the leſs enlightened and civilized nations of our own age. Satisfied with ſuch information as caſual experience threw in their way, they regarded the occupation of conſulting nature by experiment as a childiſh, trifling and uſeleſs amuſement, and neglected forming any theory whatſoever concerning its operations; but in ſucceeding times the generalizing ſpirit of Ariſtotelic Metaphyſics extending itſelf to Natural Philoſophy, ſoon ſuggeſted the notion of one common matter

* See *Roz.* journal for March, 1784, p. 206, 207, and 211.

being

being the *ſubſtratum* of all vegetable, animal and mineral ſubſtances diſcriminated only by particular forms, which in the two former were held to be *ſubſtantial*, and in the latter purely accidental. From this ungrounded opinion (to which however ſome of the greateſt men in the laſt century were much attached) that of the tranſmutability of metals into each other naturally aroſe; and to this notion, and ſome other equally falſe, the progreſs of Mineralogy, and every branch of Chymiſtry, is undoubtedly owing. To accompliſh their favourite purpoſe experiments were multiplied without end, and by means of theſe the arts of dying, pottery, glaſs-making and metallurgy were inſenſibly improved.

The two laſt named arts neceſſarily required ſome knowledge of the chymical properties of ſtones and earths. Accordingly we find that all thoſe that were uſeful in the former were called *vitrifiable*; thoſe that were capable of burning to lime *calcareous*, and thoſe on which fire could produce neither effect, *apyrous*. For a long time theſe three diviſions were thought to comprehend all ſpecies of earths and ſtones. The ſame narrow ſpirit of referring every thing to what is already known, induced Mineralogiſts to claſs all metallic ſubſtances under ſome of the ſpecies

cies antiently knewn,' denominating all those which discovered any singular properties *wild*, *rapacious* and *arsenical compounds*. Hence the opposition which the introduction of the new semi-metals, cobalt, nickel, and manganese still meets with among Mineralogists of the antient stamp.

However at last, happily for science a few distinguished characters appeared, who, rejecting all hypothetical delusions, determined, not only to submit to no other guide but actual experiment, and its necessary consequences, but also to follow it wherever it led them. Of this truly philosophic band, Mr. *Margraaf* of *Berlin* led the van, followed by a few others, particularly in *Sweden*. Discoveries now multiplied apace in the hands of a *Brandt*, *Swab*, *Cronsted*, *Gahn*, and particularly Mr. *Scheele*, until at last Mr. *Bergman* of *Upsal*, by the solidity of his judgment, the ingenuity and accuracy of his methods, and the multiplicity of his experiments, brought Mineralogy to that degree of perfection at which we at present behold it.

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CORRECTIONS.

P.	Line	
12.	14.	*Dele* they
16.	10.	*Dele* and
34.		for Species III. *read* Species IV. and correct the numerals of the other Species, as far as p. 46, where for Species XI. *read* Species XII.
36.	1.	*read* if Iron be precipitated from the ſparry acid by lime water, the precipitate will be white, &c.
36.	21.	*read* commonly cubic, ſometimes octagonal, or polygonal.
51.	6.	*for* proceeds the ſhiſtus, *read* proceeds from the ſhiſtus.
75.	21.	*for* 60 of, *read* 60 per cent of.
118.	6.	*for* parallelipedal, *read* parallelopipedal.
120.	18.	*for* parallelipeds, *read* parallelopipeds.
147.	4.	*for* rnelian, *read* carnelian.
153.	14.	*for* Metallic ſtone, *read* Metallic rock
200.	9.	*for* ſelentine, *read* ſelenite.
384.	20.	*for* 1000, *read* 10000.

Additions.

114.	3.	Mr. *Greville* poſſeſſes an agate, ſpeckled with yellow pyrites, which is called an *Avanturine.*
139.	17.	Mr. *Dolomieu* has lately diſcovered at *Stromboli*, another ſort of pumice, which ſeems to be a ferruginous granite altered by fire.

ELEMENTS

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OF

MINERALOGY.

MINERALS in their ſtricteſt ſignification denote only ſuch ſubſtances as are found in mines, ſuch as Metals, Semi-metals, Sulphur and Salts; but in a more extenſive ſenſe, they denote all foſſils that do not belong either to the vegetable or animal kingdoms, and conſequently Stones and Earths, all of which are comprehended under the Denomination of the *Mineral kingdom*.

The mineral kingdom is therefore uſually divided into four parts or claſſes, *viz.* I. *Earths, and Stones.* II. *Salts.* III. *Inflammable Subſtances.* IV. *Metallic Subſtances:* which naturally point out a ſimilar fourfold diviſion of this treatiſe.

PART I.

Of EARTHS *and* STONES.

By *Earths* are commonly underſtood taſteleſs, inodorous, dry, brittle, uninflammable ſubſtances, whoſe ſpecific gravity does not exceed 4,5. which are incapable of being metalized, are ſcarcely ſoluble in water, and give no tinge to Borax when melted with it. However Quicklime is uſually called an *Earth*, though it has a pungent taſte and is very perceptibly ſoluble in water, ſo alſo are limeſtone and gypſum, though they both contain a purely ſaline principle, and therefore in my opinion they and ſome other ſuch ſubſtances may be claſſed both among Salts and among Earths. Nay it appears that all Earths are ſoluble in ſome very large proportion of water. Hence I think with *Mr. Bergman*, that in the ſtricteſt ſenſe the term Earth, ſhould, excluſively of any other denomination, be appropriated to ſubſtances of the above deſcription, that require above one thouſand times their weight of boiling water to diſſolve them, and that thoſe which are ſoluble in between four hundred and one thouſand times their weight of water may be called either ſalts as technical, or Earths as common language requires.

Stones differ from Earths only in hardneſs and its conſequences, and therefore are included under the ſame generical name. Yet diamond is alſo called a Stone, though it probably contains little Earth of any kind.

CHAP. I.

Of Simple Earths, their number and Characters.

By *ſimple* Earths, I mean thoſe which poſſeſſing permanently diſtinct characters, are incapable of being further analyzed or changed into any other, by any means hitherto known. Of theſe, we know only five. The *Calcareous*, the *Ponderous*, the *Magneſian* or *Muriatic*, the *Argillaceous*, and the *Siliceous*. All Stones and Earths hitherto examined, are found to conſiſt of theſe either ſingly, or mixed, or chymically united with each other, in various proportions, together with ſaline, inflammable and metallic ſubſtances; for in the Earth they are ſeldom or ever found perfectly pure.

Of the Characters of Calcareous Earth.

1st. When perfectly pure and free from all combination, it conſtitutes *lime*; its ſpecific gravity is about 2,3. it has a hot burning taſte, acts powerfully on animal ſubſtances,

and when in lumps, heats with a moderate quantity of water.

2[d.] In the temperature of 60° it requires about ſix hundred and eighty times its weight of water to diſſolve it; its taſte is then pungent, urinous, yet ſweetiſh.

3[d.] It is combinable with all acids, and in particular eaſily ſoluble in the nitrous or marine, but difficultly cryſtalizes with them, as it forms deliqueſcent ſalts, and is in great meaſure precipitable from them by the vitriolic, to which it preferably unites, forming gypſum or ſelenite, which is wholly precipitable from them by the affuſion of highly rectified ſpirits of wine, or moderate evaporation, nitrous ſelenite eaſily parts with its acid, when calcined in open veſſels and a red heat; but marine ſelenite ſcarcely. Both ſelenites have a bitter taſte.

4[th.] When in veſſels on which it cannot act, it is infuſible *per ſe* (that is ſingly;) in a heat that would melt iron: yet *Mr. Parker's* glaſs ſeems to have induced a ſlight beginning of fuſion in lime, even when it ſtood on charcoal, but if mixed with argillaceous, magneſian or ſiliceous Earths, it will melt in a more moderate heat, and particularly if mixed with two or more of thoſe Earths. And hence

hence it is fuſible in earthen veſſels, even of porcelain ; it is ſcarcely affected by fixed alkalis, but eaſily melted and without effervefcence by borax or microcoſmic ſalt, or calces of lead.

Ponderous Earth.

1st. This may more conveniently be called *Barytes*, when pure it is alſo in the ſtate of lime, which it perfectly reſembles in taſte, but it requires nine hundred times its weight of water to diſſolve it in the temperature of 60°.

2d. It is combinable with acids, but with the nitrous and marine, it forms ſalts that do not deliqueſce, and with the vitriolic, a ſalt much more difficultly ſoluble than gypſum, it decompoſes tartar vitrolate, an effect which no other Earth can operate.

3d. It is precipitable from the nitrous and marine acids by the Pruſſian Alkali, a property which alſo diſtinguiſhes it from all other Earths.

4th. In the dry way it acts and is acted upon nearly as calcareous Earth, but it is ſomething more fuſible by the mineral alkali. Its ſpecific gravity exceeds 4,000.

Magnesia or Muriatic Earth

1st. Its specific gravity when perfectly pure is about 2,33.

2d. It requires about seven thousand six hundred and ninety-two times its weight of water to dissolve it in the common temperature of the air.

3d. It is combinable with acids, and though the vitriolic easily separates it from the nitrous and marine, yet it does not precipitate it, as it does calcareous Earth and barytes, but forms Epsom salt which is bitter and soluble in its own weight of water; whereas with the former Earths it forms insipid and very difficultly soluble compounds.

4th. Exposed to the strongest heat, it will neither burn to lime, nor melt *per se*, but loses much of its weight, partly by evaporation, and partly by the loss of a certain proportion of water, which it naturally retains. Neither will it vitrify in company with any other simple Earth, except the calcareous, of which, according to *Mr. Achard* 100gr. will promote the fusion of from twenty-five to fifty of magnesia, it will also melt with argillaceous and siliceous Earths together, and much more readily if calcareous Earth be added to them. Like lime

lime it is brought into fusion by borax or microcosmic salt, but is scarcely affected by fixed alkalis, or calces of lead.

Argillaceous Earth or Earth of Alum.

1st. This may more conveniently be called *Argill*, its specific gravity when pure does not exceed 2,000.

2d. It is exceedingly diffusible, but scarcely more soluble in water than pure magnesia.

3d. It is combinable with acids, and when combined with the nitrous or marine, like magnesia it is separable, but scarcely precipitable by the vitriolic acid * with which it forms Alum, which always contains an excess of acid and has an astringent taste; when combined with any of these acids, it is not precipitable by the acid of sugar, which distinquishes it from the foregoing Earths, all of which (except the ponderous united to the vitriolic acid) are precipitable from the vitriolic, nitrous and marine acids, by that of sugar, though the precipitation is not always apparent before the liquors are evaporated, nor at all, if there be an excess of the mineral acids.

* For if concentrated oil of vitriol be droped into a very saturate solution of nitrous or marine Alum, a greyish precipitate will immediately appear.

4th. The ſtrongeſt heat barely hardens it, but does not give it the qualities of lime, nor melt it, while ſingle, or accompanied only with magneſia or ſiliceous Earth ; but mixed with calcareous, it runs into fuſion very readily, and hence *Mr. Gerhard* has found it fuſible in a crucible of chalk, but not in one of clay; fixed alkalis do not promote its fuſion, but borax and microcoſmic ſalt diſſolve it, the firſt with ſcarce any, and the latter with a more notable efferveſcence. Calces of lead affect it ſomething leſs than they do calcareous Earths.

Siliceous Earth.

1ſt. This is by ſome called cryſtaline, quartzy, or vitrifiable Earth, as it is that of which glaſs is uſually formed ; its ſpecific gravity is 2,65, and conſequently it is the heavieſt of all the ſimple Earths, except the barytes.

2d. It ſeems leſs ſoluble in water than any other, yet in the common temperature of the atmoſphere ten thouſand parts of water may contain one of this Earth ; and in very high degrees of heat, much exceeding that at which water uſually boils, it ſeems ſoluble in a much greater proportion.

3^d. It combines with no acid hitherto known, except the ſparry, which either in a liquid or aerial ſtate, but particularly in the latter, is capable of holding much of it in ſolution, which it depoſits either on cooling or coming in contact with water, or ſubſtances with which it has a greater affinity. But cauſtic fixed alkalis may even in the liquid way take up from $\frac{1}{10}$ to $\frac{1}{6}$ of their weight of this Earth according as it is more or leſs ſubtilly divided, and hence it is not improbable that even lime-water has ſome action on it.

4th. It is infuſible *per ſe* in the ſtrongeſt heat, neither does argillaceous or magneſian Earths promote its fuſion, the effect of calcareous Earth is ſomewhat more doubtful, for *Mr. Achard* * and Mr. *Scheffer*,† aſſert that theſe Earths do not melt together, but *Mr. Darcet*,‡ and alſo Mr. *Bergman*,§ and Mr. *Swab*, || ſay that two parts lime melt one of quartz; at leaſt there is no doubt but this may be effected in veſſels of clay, for an admixture of this will make the other two Earths immediately yield. Fixed alkalis, particularly the mineral, readily melt double their weight of this Earth with efferveſcence, borax affects it more difficultly, and with ſcarce any efferveſcence, and microcoſmic ſalt has hardly any action

* Mem. Berlin, 1780, p. 32. † Foreles. § 175, b.
‡ 22 Roz. p. 27. § Scheſſ. Foreles. § 175, b. 2 Anmerk.
|| 2 Memoires d'Upſal, p. 443.

on

on it; calces of lead act on it more powerfully than on argill, but leſs than on calcareous Earth, and melt from $\frac{1}{3}$ to $\frac{1}{2}$ their weight of it.

The calcareous, ponderous magneſian and argillaceous Earths being combinable with all acids, may be called *abſorbent* Earths, in contradiſtinction to the ſiliceous, which unites only to the ſparry acid.

Beſides the general characters of theſe Earths, here given, *Mr. Bergman* has obſerved and noted their different powers of abſorbing and retaining water; after moiſtening equal weights of ſiliceous ſand, chalk, magneſia, and Earth of alum, with as much water as they could take up without dropping, he found that the ſand took $\frac{1}{4}$ of its weight, chalk $\frac{1}{2}$, magneſia $1\frac{1}{20}$, and Earth of alum $2,\frac{1}{2}$, and when all theſe moiſtened Earths were expoſed to the ſame heat, the ſand loſt its water firſt, then the chalk, then the magneſia, but the argill, not until red-hot.

Again one of the characters of argillaceous Earth is the extreme ſubtility and fineneſs of its integrant parts, which render it ſmooth to the touch, and ſlowly ſeparable from water when diffuſed through it, alſo a certain viſci-

dity

dity and ductility which proceed from its power of retaining water, and of these properties magnesia also participates though in a lesser degree. Siliceous Earths on the contrary are characterised by roughness, hardness, sharpness to the touch, and a total want of flexibility and adherence to each other, when minutely divided, and a ready separation from water; of these properties calcareous and ponderous Earths participate, though in a lesser degree.

CHAP II.

Of the Affinities of Earths to each other.

The above mentioned Earths are never found in nature perfectly pure, but always combined or mixed either with a saline or inflammable principle, or with each other, or with some metallic principle, particularly iron, besides water; when mixed with any notable proportion of the inflammable or metallic principles, or even of the saline, so as to exhibit the characters of such principles, they shall be treated of under those particular heads; I shall here consider only such compounds as retain the general characters of Earths, and as in conformity with *Mr. Cronsted*, I intend deducing the various *species* of Earths from their union either with saline principles or with each other, it will be necessary to indicate the affinities on which such unions are founded;

founded; the affinities of Earths to acids are generally known, but thofe of Earths to each other and to calces of iron have no where been treated of; and therefore require fome developement.—The efforts of art can fcarcely exhibit in the *humid* way, the affinities of Earths to each other, if this could be effected, we fhould probably find the fame election and preference take place among them as among Earths and acids, we are therefore obliged to have recourfe to the *dry* way, which is much more imperfect: for as they are all reduced by fire to a ftate of liquidity, they differ but little in fpecific gravity, and can difficultly be examined while in fufion, when cold they are all found fo mixed that it is not poffible to judge of their affinities by the way of preference and exclufion; but if we judge of thefe affinities as we do of that of water to falts, by the greater or the leffer quantity which one of them confidered as a menftruum, can take up of another or what proportion of the one determines the fufion of another, we may in that manner form a tolerably accurate idea of their different attractive powers.

Among the fimple Earths, the calcareous alone,* can be looked upon as the menftru-

* Perhaps the ponderous may alfo have this property, but it being fcarce, no experiments have yet been made with a view to determine this point.

um of other Earths, for according to the important diſcovery of *Mr. D'Arcet*, they are all rendered fuſible by a proper proportion of this Earth, though infuſible of themſelves. A diſcovery which throws the greateſt light, not only on mineralogy, but alſo on metallurgy and the arts of vitrifaction and pottery; now calcareous Earth requires for its fuſion half its weight of magneſia, and only ⅓ of its weight of argillaceous Earth, according to the experiments of *Mr. Achard.*† He did not indeed obſerve that it had any effect on ſiliceous Earth, but this appears to be owing to his having uſed too ſmall a proportion of the calcareous, for *Mr. Gerhard*‡ having expoſed ſiliceous Earth to a violent heat in a crucible of chalk, found it vitrified in the edges where it touched the chalk, but we may infer that this Earth is leſs acted upon and more difficultly than the foregoing; even in the liquid way, calcareous Earth in ſome caſes manifeſts the ſame affinities, thus if Earth of alum perfectly pure be added to lime water, it will precipitate the lime as *Mr. Scheele* has ſhewn in the Memoirs of Stockholm, for 1776, and the precipitate is ſoluble in the marine acid, which ſhews that the precipitation does not ariſe from any remains of the vitriolic acid in the Earth of

† Mem. Berlin, 1780. ‡ 2 Geſch. Mineral Reich.

alum,

alum, as gypſum in that caſe would be formed, which is inſoluble in the marine acid, but pure magneſia, that is, free from aerial acid, does not precipitate lime water.

Siliceous Earth ſeems alſo to have ſome affinity to the argillaceous, for although it cannot be brought into fuſion by the argillaceous, yet when melted by fixed alkalis it acts on the argillaceous Earth of the crucibles and diſſolves it; now fixed alkalis ſingly, cannot melt argillaceous Earth; to ſay nothing of the hardening power of argill and ſiliceous Earths, when mixed together and heated.

Iron in a more or leſs dephlogiſticated ſtate, being found in ſome proportion mixed or united with almoſt all ſorts of Earths and Stones, deſerves alſo to have its affinities to them mentioned, it is much more fuſible than any of them, and may therefore be conſidered as a menſtruum. *Mr. Achard* has found that an hundred parts of calx of iron are capable of melting four hundred of calcareous, fifty of argillaceous, thirty-three of ſiliceous and twenty-five of magneſian Earths, it acts ſtill more powerfully on leſſer proportions of theſe Earths.

Hence,

Hence the affinities of theſe Earths, and calces of iron to each other, ſeem to me to ſtand in the following order.

Lime,	*Magneſia,*	*Argill,*	*Silex,*	*Calx of Iron.*
Calx of Iron,	Lime,	Calx of Iron,	Calx of Iron,	Lime,
Argill,	Calx of Iron,	Lime,	Lime,	Argill,
Magneſia,		Silex,	Argill,	Silex,
Silex,				Magneſia.

When ſubſtances are diſſolved and at liberty, their affinities whether in the moiſt or dry way, are exactly the ſame, they being equally divided; and the only difference is, that in one caſe, they are diſſolved by fire, in the other by a liquid. We may alſo obſerve, 1ſt, that the leſs calces of iron are dephlogiſticated, the greater is their power of attracting Earths as *Mr. Rinman* has diſcovered, and when dephlogiſticated to a certain degree, they loſe this power, their colour according to the degree of their dephlogiſtication is as follows, whitiſh, pale yellow, yellow, red, brown, green, and blue. 2dly. That when once lime or calces of iron have acted as menſtrums upon any Earth, a compound menſtruum ariſes, which acts much more powerfully on other Earths; thus, though one hundred parts of lime can diſſolve or liquify very little of ſilex, yet when theſe hundred parts of lime have taken up fifty of magneſia, they are enabled to diſſolve one hundred of ſilex, and this

this laſt compound forms a menſtruum ſtill more compound, which is able to diſſolve ſtill more of magneſia, for equal parts lime, magneſia, and ſilex form a perfect glaſs; and hence equal parts of any three of the ſimple Earths will vitrify in a ſufficient heat, ſo that calcareous Earth be one of the three; nay one part lime and one of argill will melt 2 or 2½ of ſilex, and other mixtures are more or leſs fuſible as they approach to this proportion.

The principal marks of Chymical Union are the following.

1ſt. *A ſpecific gravity* exceeding that of the heavieſt of the ingredients of the compound, or even greater than the intermediate. But it does not follow that, where ſuch denſity is wanting, a chymical union does not exiſt, for the peculiar ſtructure of the compound which does not admit water into its vacuities may hinder this property from being obſerved, ſo may alſo a certain quantity of water which enters into the compoſition, and cannot always be made ſenſible.

2d. *Tranſparency*, when this property is found in combinations of Earths with each other, or with ſaline ſubſtances, it indicates a chymical union; but ſuch an union is alſo conſiſtent

consistent with opacity, as this may arise from a mere mechanical arrangement of the parts, or the interposition of some that are not chymically combined, too great thickness, &c.

3[d.] *Crystalization.* This proves that the parts of the chrystalized substances have been at some period very minutely divided; and in general that they have been chymically combined with the menstruum, in which they chrystallized; though I agree with *Mr. Bergman* that a chymical union with such a menstruum is not always requisite; but it does not prove that they were chymically combined with any other substance which chrystallizes with them, except some other mark of such union appears, and particularly a density greater than could be expected from the proportion and density of the component parts.

4[th.] *A more difficult Solubility* in their common menstruums, and of course a still greater difficulty of solution in menstruums, that act only on one of the component parts. Of this there are numberless instances, yet there is one exception, viz. where one of the component parts is resolvable by the action of the menstruum into an elastic fluid, which by its eruption so powerfully agitates and

divides the compound, as to render it more ſoluble. Thus lime-ſtone, and mild magneſia, are more eaſily diſſolved than either lime or calcined magneſia. On the other hand, ſome metallic calces are more eaſily diſſolved in certain acids, than they are when furniſhed with phlogiſton, though this alſo be reſolvable into an elaſtic fluid; but this I have elſewhere explained. The calces of iron are ſo much the more difficultly diſſolved, as they are more dephlogiſticated; hence the whitiſh calx is moſt difficultly diſſolved; and next to that the yellowiſh and red; but the brown, green, and blue, moſt eaſily; and hence, ſtones which contain dephlogiſticated calces of iron and unareated Earths, are moſt difficultly diſſolved, though the calces are not ſo ſtrongly attracted by the Earths, nor conſequently the ſtones ſo hard, as thoſe that contain iron in a more phlogiſticated ſtate. This accounts for the difficult ſolubility of talc, mica, &c.

CHAP. III.

Of the Syſtematical Arrangement of Earths and Stones.

All Earths may be divided into ſimple and compound. Simple are the five unalterable kinds already deſcribed, which conſtitute five ſorts or *genera*, under which all terrene compounds may be ranged.

By

By *Compound Earths*, I underſtand thoſe that are combined or mixed in a *notable* proportion, either with each other, or with a ſaline, inflammable, or metallic principle, yet not in ſufficient proportion to require them to be arranged under ſuch foreign principles. Such compounds being permanent, and being the foundation of a peculiar denomination, I call *ſpecies*, and ſimple ſpecies, in order to diſtinguiſh them from ſuper compounds, which will preſently be mentioned. Thus *gypſum* is a compound Earth, conſiſting of calcareous Earth, and a ſaline principle, not accidentally, but permanently mixed with it. So alſo tourmaline is a compound Earth, conſiſting of the argillaceous, ſiliceous, and calcareous, and iron, in proportions determined within certain limits, and forms a ſimple ſpecies. I ſaid a *notable* proportion, becauſe it is difficult to aſſign this proportion with preciſion; for it relates to denominations of ſubſtances, and theſe are founded on the neceſſity of diſtinction, ariſing ſometimes from the uſefulneſs of ſubſtances to mankind, and ſometimes from caprice. Thus, a compound Earth, which ſhould conſiſt of calcareous Earth, and only two per cent. of gold or ſilver, would be denominated an *ore*, whereas, if it contained only two per cent. of iron, or of another Earth, it would ſtill retain the name of, and be reckoned among, calcareous Earths. However, in general we

may ſay, that any proportion which produces peculiar effects, or is the foundation of ſome particular uſe, is *notable.* When iron is found in any Earth or Stone, in the proportion of 14 or 15 per cent. it commonly renders it magnetic, either before or after torrefaction, according to its ſtate of phlogiſtication; and if it be found in the proportion of 30 per cent. or more, it gives the compound the denomination of an *ore.* To ſtones that contain a greater quantity of iron than is eſſential to them in the pureſt ſtate, I add the denomination *martial,* or *ferruginous.*

When ſimple Earths, belonging to different *genera,* are mixed or combined with each other, I generally place them under that *genus* of which the compound contains the largeſt proportion, yet not always, for if the compound poſſeſſes the peculiar characters of the component part, which is in a ſmaller proportion; or if it attracts the attention, and is ſubſervient to the uſes of mankind, merely on account of the leſs copious ingredient, I range it under the *genus* of that ingredient. Thus, though common clay contains much more of ſiliceous than of mere argillaceous Earth, yet, as it poſſeſſes ſmoothneſs, viſcidity, and ſoftneſs, in a high degree, it would appear ridiculous to place it under the ſiliceous genus, whoſe characters are the very reverſe. For the ſame reaſon, I place the precious

precious ſtones under the ſiliceous genus, though the argillaceous be, in point of proportion, predominant in their compoſition.

By *ſuper-compound* Earths or Stones, I mean aggregates of *viſibly different ſimple ſpecies*, in a notable proportion, whether theſe ſpecies belong to the ſame, or to different *genera*. Thus I would call a compound of gypſum and fluor ſpar a ſuper-compound, though both belong to the calcareous genus; and *a fortiori* granites and porphyries, which form aggregates of ſimple ſpecies belonging to different *genera*. Super-compounds, therefore, form *compound ſpecies*, which may be ranged under that genus which is found in them in greater proportion. In general they may be known by the eye, at leaſt when aided by a lens.

In ſtrictneſs, Earths of different *genera*, each of which contain the aerial acid, ſhould, when mixed with each other, conſtitute a compound ſpecies, yet, as this acid is eaſily expelled, and cauſes no great difference in the properties of the compound, and as in fact abſorbent Earths, when combined with no other ſaline principle, are ſeldom without it, I ſhall rank thoſe compounds among the ſimple ſpecies, and ſo I ſhall quartz and ſilex, though ſeldom abſolutely pure.

CHAP. IV.

Calcareous Genus.

SPECIES I.

Calcareous Earth, uncombined with any Acid.

This ſtone is of a grey colour, moderately hard, or rather ſoft, found near Bath; it is mixed with calcareous Earth combined with fixed air; and hence it efferveſces with acids, but at the ſame time it is ſoluble in water, to which it communicates the taſte of lime; and if this ſolution be mixed with ſulphur, it diſſolves it, and forms a calcareous liver of ſulphur, with the aſſiſtance of heat; whence it is plain that part of the calcareous earth is in an uncombined ſtate. See *Falconer* on Bath Waters, vol. i. p. 156 and 257. When expoſed to the air for ſome time, it hardens, by attracting a ſufficiency of the aerial acid. I have obſerved ſeveral lime-ſtones to have the ſame property of hardening ſome time after they have been dug. *Mr. Monnet* alſo found this Earth in a looſe, dry, powdery form, of a yellowiſh colour, in the mountains of Auvergne, and ſuſpected it to be of volcanic origin. *Mineralogie*, p. 515.

Species II.

Combined with the Aerial Acid.

This ſpecies comprehends a great variety of external appearances, the moſt remarkable of which are tranſparency and opacity, hence I ſhall divide it into two ſeries, the tranſparent and opake; all efferveſce with acids; none give fire with ſteel; the chryſtalized decrepitate when heated.

Series I.

Tranſparent Spars.

These are of a lamellar texture, and moſtly break or ſplit into rhomboidal laminæ; and this ſtructure is generally called ſpathoſe, or ſparry. They are found cryſtallized in various forms, rhomboidal, hexangular, triangular, polyangular; but the moſt common is the rhomboidal, of which ſort is the Iceland cryſtal, which poſſeſſes a double refracting power.

Their ſpecific gravity is generally about 2,700, when pure from metallic particles; and they generally contain from 34 to 36 per cent. of the aerial acid, from 53 to 55 of mere Earth, and the remainder water.

 Theſe

These ſpars when pure are always colourleſs, but ſometimes they are found green, brown, reddiſh, yellowiſh, and even black, from a mixture of metallic particles.

De la Hire and *Huygens*, denote rhomboidal ſpar under the name of talc.

SERIES II.

Opake.

Under this ſeries I range a variety of ſtones of the ſame ſpecies, but which are known under various denominations arriſing from external properties, or the apparent mode of their origination; ſuch as opake-ſpars, ſtalacttites, tophuſes, incruſtations, petrifactions, agaric-mineral, chalk, limeſtone, marble.

Opake Spars.

Theſe are chryſtalized under the ſame regular forms as the tranſparent ſpars, and ſometimes appear in a globular form; their texture is alſo lamellar, they are of different colours like the foregoing; the red frequently receive that tinge from mangane ſe. 16 *Roz.* 15.

Stalactites,

Stalactites, Sinter Calcareum, Stiria.

Theſe are found ſuſpended from vaults, being formed by the oozing of water charged with calcareous particles, and gradually evaporating, leaving thoſe particles behind; this depoſition can ſcarce be called a chryſtalization, as the calcareous particles do not appear to have been diſſolved, nor even very minutely divided, though this ſometimes happens, whereas tranſparent ſpars appear to have been formed from a ſolution in water, by means of the aerial acid. Stalactites are of a lamellar or granular texture, and either in a branchy form, or in that of perforated cones, or globular, and then called *ſtalagmites*, *oolithes*, *piſolites*, &c. Moſt of theſe ſtones contain a ſlight mixture of argill and calx of iron. And hence are of a grey, brown, yellow, or blackiſh colour.

Tophi, Duckſtein of the Germans, Pori.

Theſe differ from the former, not only in ſhape, but principally in this, that they have been formed by a gradual depoſition of Earths, chiefly of the calcareous kind, barely diffuſed through water, within the water itſelf and not in air. Hence they are of a ſoft and porous texture, and of the ſame colour

colour as the foregoing, the pureſt ſorts alone are placed here.

Calcareous Incruſtations.

Theſe are generally found on branches or roots of trees, and ſometimes on ſtones of different kinds, the moſt remarkable of theſe incruſtations is that found on the roots of pines, called *Oſteocolla*, which Mr. *Margraaf* found to conſiſt chiefly of calcareous Earth, mixed with a ſmall proportion of ſiliceous, and volatile alkali, together with ſome vegetable parts.

Calcareous Petrifactions.

Theſe conſiſt of calcareous ſtones, in the form of animal or vegetable ſubſtances, the former are called *Zoophytes*, the latter *Phytholites.*

The moſt remarkable of the former are, 1ſt, Thoſe of the *Coral* claſs, of a ramified and tubular form as coral, madrepores, millepores, aſtroites 2d, Thoſe of the claſs of ſea worms, belemnites, which are of a conic or cylyndrical form. *Aſteriæ* and *Entrochi*, which have a ſtarry appearance. 3d, Thoſe of the teſtaceous claſs, as *nautilites*, *ammonites*, *echini*, &c.

Agaric Mineral, Guhr.

This fanciful name denotes only a looſe calcareous Earth found in the clefts or cavities of rocks, moſtly white, but ſometimes red or yellow, from a mixture of clay or ochre.

Chalk, Craie, Craie de Champagne, blanc d'Eſpagne of the French.

This ſubſtance is too well known to need any deſcription, the pureſt is *white*, yet it contains a little ſiliceous Earth, and about two per cent. of argill. Mr. *Rinman's* Hiſtory of Iron, § 201, mentions a blue chalk found in the neighbourhood of *Upſal*, which contains iron. Mr. *Beaumé* ſays that the pureſt calcareous Earths he has met with contain ſome ſmall proportion of iron, which depoſits from ſolutions long made. 1 *Beaumé* 255. however I have frequently uſed chalk, in whoſe ſolution neither galls nor Pruſſian alkali could diſcover any. Dry chalk contains more aerial acid than any other of the calcareous claſs; generally about forty per cent. its ſpecific gravity is from 2,4, to 2,65.

Limeſtones,

Limeſtones, Albareſe of the Italians.

All ſtones which are uſually burned to lime, are comprehended under this name; ſome are of a lamellar and ſome of a granular texture; their colours are various, the pureſt are white, grey, or bluiſh grey, their proportion of aerial acid is ſomething greater than that in ſpars, and all contain ſome ſmall proportion of argill, quartz and iron. 18 *Roz.* 345, Mr. *Meyer* aſſerts, that in the pureſt limeſtones he has examined, theſe foreign ingredients amounted to about four per cent. he alſo ſays that he has found marine Epſom and ſea ſalt in ſome ſmall proportion in all of them. 1 *Meyer*, 5,20, and 21. Some limeſtones found in *Scania*, contain orpiment according to *Scheffer's* account. Among limeſtones we may reckon, that called St. Stephen's ſtone by *Cartheuſer* and *Vogel*, becauſe it has ſome red ſpots on its ſurface reſembling blood; the lamellar limeſtones uſually contain petrifactions, chiefly of marine animals and alſo ſhells; the ſpecific gravity of limeſtones is from 2,65, to 2,70, generally.

Ketton Stone is a remarkable ſpecies of limeſtone, conſiſting of very ſmall globules like the roe of fiſh, concreted together. Hence

Hence its ſpecific gravity is only 2,456, and it is called *Hammites*, it contains ninety per cent. of mild calcareous Earth, and ten per cent. of argillaceous Earth ſo firmly united to red calx of iron, as to be difficultly ſoluble even in aqua regia; the proportion of iron is not above one per cent. in this ſtone, and yet it ſenſibly colours it.

Portland Stone, and *Purbeck* Stone belong alſo to this claſs, the ſpecific gravity of the former is 2,533, and of the latter 2,680, according to the experiments of Dr. *Watſon*, who accordingly found that the latter afforded more lime, 2 *Watſon's* Eſſays, 190. Portland Stone is of a dull white colour, looſe open porous texture, eaſily cut, and contains a ſmall proportion of ſilex. *Bath* Stone reſembles the Portland, but its texture is more granular and open; its ſpecific gravity 2,494.

Calcareous Flag-ſtone, otherwiſe called calcareous ſchiſtus. That found near *Woodſtock*, and uſed for covering houſes, is of a yellowiſh white colour and moderately hard, its ſpecific gravity is 2,585, contains a little clay and more iron than the *Portland* Stone.

Marbles.

Marbles.

Opake ſtones of any ſort, ſomething harder than limeſtones, more compact, of a cloſer grain and ſuſceptible of a good poliſh, have been called *Marble* by ſtatuaries, but this name is now appropriated to ſtones of the above deſcription, of the calcareous genus only. The ſpecific gravity of Marbles is from 2,7 to 2,8, their texture like that of limeſtones is either lamellar or granular and their colours various, not only in different maſſes, but in one and the ſame piece; theſe laſt will be mentioned among the compound ſpecies: when the different ſpecies are in large diſtinct maſſes they are called *Breccias*, Marbles of three colours, grey, yellow, and black; which abound in petrifactions, are called *lumachellis*; thoſe of four colours, white, grey, yellow and red, are called *Brocatello's.* I ſhall here only mention the purer ſorts that contain the leaſt mixture of foreign genera.

White Marble, particularly that of *Carrara*, is the pureſt with which we are acquainted; it is of a granular texture and ſparkling in its fracture like ſugar; its ſpecific gravity is 2,7175, of this ſort is the *Pietra Elaſtica* of *Rome*. *Ferber*, *Italy*, 130. Other white marbles are not ſo pure, many are of a lamellar texture.

Black.

Black. This colour is commonly owing to a ſlight mixture of Iron. Mr. *Bayen* found one ſpecimen of it to contain five per cent. of iron, yet the lime made of it was at firſt white, but in time acquired an ochry, or reddiſh yellow colour, 11 Roz. 496.

Mr. *Bergman* remarks, that all calcareous ſtones which grow black or brown by calcination, may be ſuſpected to contain manganeſe, in that caſe the lime they form is excellent as a cement. 2 *Bergman*, 229. And according to *Rinman* (Hiſtory of Iron, § 189,) white calcareous ſtones, that grow black by calcination, contain about ten per cent. of iron.

Grey. This ſort of marble contains leſs iron, only one or two per cent. according to Mr. *Bayen.*

Blue and *Green* marbles derive their colour from a mixture of ſhorl, according to Mr. *Rinman*, *Hiſtoria ferri.* § 201. 206.

SPECIES III.

Combined with the Vitriolic Acid.

Gypſum, Selenite, Plaiſter of Paris.

This ſpecies is of different colours, moſtly white or grey, of a lamellar, granular, or fibrous

fibrous texture, of a moderate hardneſs, not ſo great as to give fire with ſteel; ſometimes opake, ſometimes pellucid, ſometimes regularly chryſtalized, and ſometimes amorphous.

Its ſpecific gravity is 2,32 generally, ſometimes only 1,87.

It is ſoluble in about five hundred times its weight of water, at the temperature of ſixty. It does not efferveſce with acids, and is difficultly ſoluble in any, particularly in the marine.

When heated a little below ignition, it undergoes a motion ſimilar to that of ebullition, from the diſſipation of its aqueous part, and falls into powder; if taken up when this motion ceaſes, and ſprinkled over with water, it ſoon concretes and hardens, by reaſon of its ſudden chryſtalization.

If calcined with ¼ of its weight of charcoal, it yields a liver of ſulphur, and the Earth thus ſeparated, treated with black flux, frequently yields a little of Iron: it is fuſible *per ſe* by the blow pipe. 2 *Bergman*, 469, or in a long continued porcelain heat, 22 *Roz.* 26, though Mr. *Gerhard* ſays this does not happen in crucibles of chalk, but only in thoſe of clay. 2 *Gerb. Geſch.* 16.

It

It contains about 30 per cent. vitriolic acid, 32 of mere Earth, and 38 of water; of which it parts with about 20 by calcination. The beſt method of decompoſing it is to boil it, well pulverized, in a fixed alkaline lye.

The varieties of its external appearances may be preſented under two ſeries, the tranſparent and opake.

SERIES I.

Tranſparent.

Lapis Specularis, Vitrum Ruthenicum, Glacies Mariæ, Stirium Pellucidum, Gypſum Spathoſum Diaphanum.

This is either colourleſs, or yellowiſh, green, or reddiſh; which laſt colour is from iron, as *Mr. Morveau* has, by means of vinegar, completely ſeparated it. Its form is either amorphous, or regular, generally cubic; its texture lamellar, ſcaly, or fibrous.

SERIES II.

Opake.

The colour of this is either white, grey, yellowiſh, greeniſh, or black; its texture

D ſcaly,

ſcaly, fibrous, or granular; its ſhape either regular as cubic, rhomboidal, or priſmatic, conſiſting of three or five ſides; or amorphous, of which ſort is *alabaſter*, whoſe texture is granular, with ſhining particles, and its ſpecific gravity 1,87.

SPECIES III.

Combined with the Sparry Aci

Fluor, Spathum fuſibile, Petunſe of Margraaf, 2 *Theil.* p. 45, *Blue John.*

Its colours are various, being either white, yellow, blue, green, reddiſh, purple, brown, or colourleſs; its texture ſparry or ſhattery; its form either amorphous or regular; its hardneſs not ſo great as to give fire with ſteel; its ſpecific gravity from 3,14 to 3,18; if greater it proceeds from a large proportion of metallic or other foreign particles.

It is inſoluble in water, does not efferveſce with acids, and is ſcarcely ſoluble in them without decompoſition.

When heated it decrepitates and burſts, but does not yield lime, nor harden by the affuſion of water, as gypſums do. The coloured fluors become phoſphoreſcent when heated ſlowly,

ſlowly, below ignition, but loſe this property when made red hot, and alſo on cooling. It melts *per ſe* in a ſtrong heat, and violently attacks the crucibles, as it powerfully promotes the fuſion of argillaceous Earths. It is alſo fuſible with mineral alkali, borax or microcoſmic ſalt, and without effervеſcence. It conſiſts of the ſparry acid, water, and calcareous Earth. According to *Mr. D'Arcet*, the acid is in the proportion of 16 per cent. 22 *Roz.* 24. and according to *Mr. Scheele*, 100 gr. of fluor contain about 57 of mere Earth, and conſequently about 27 of water; but I believe it contains much leſs water, and much more acid, for a great deal of the acid pierces through the luting during diſtillation.

It is decompoſed by diſtilling it with three times its weight of concentrated vitriolic acid, but to obtain the ſparry acid pure, it ſhould be diſtilled with its own weight of that concentrated acid pure and colourleſs, at firſt with a gentle, and towards the end with a ſtrong heat, placing water in the receiver, in the proportion of 10 or 12 times the weight of the ſpar. The nitrous and marine acids decompoſe it if dilute, but not when theſe acids are concentrated.

Blue fluors derive their colour moſtly from iron, but ſometimes from cobalt. 2 *Berlin. Beſchaft.*

Beſchaft. 330; and in fact, iron, precipitated from the ſparry acid by lime water, is white, with blue ſpecks. Green fluors owe alſo their colour to iron. *Rinman*, § 206.

Moſt fluors contain a mixture of argillaceous and ſiliceous Earths, and ſome marine acid. The ſiliceous Earth, which ſublimes in diſtilling theſe ſpars, ariſe, from the ſolution of that pre-contained in the ſpar, or from the corroſion of the glaſs veſſels, as Meſſrs. *Mayer* and *Wiegleb* have ſhewn; this acid poſſeſſing the ſingular property of diſſolving ſiliceous Earths, and conſequently glaſs.

The varieties of this ſpecies may be reduced to two, the tranſparent and opake; of which there are neceſſarily many intermediate ſhades.

Series I.

Tranſparent.

Theſe are generally of a regular ſhape, cubic, rhomboidal, polygonal, and of different colours; and hence called pſeudo-emeralds, ſapphires, topazes, amethyſts, &c.— Some are amorphous.

Series II.

Opake.

These are diſtinguiſhed by the ſame colours; their texture alſo is generally the ſame, but it is ſaid to be ſometimes granular; their form is alſo regular, or amorphous, like the foregoing.

The phoſphoreſcent property of fluors ſeems to ariſe not from the acid ſingly, otherwiſe all fluors would poſſeſs it, but from the acid, in contact with metallic particles, and conſequently from the acid and phlogiſton.

Species IV.

Combined with the Tungſten Acid.

Tungſten, Lapis Ponderoſus, Schwerere Zingraupen of the Germans.

When pure it is of a grey colour and lamellar texture, gives fire with ſteel, and is very weighty, its ſpecific gravity being from 4,99 to 5,8.

It is inſoluble in acids, except by peculiar management; when powdered and digeſted with

with the nitrous or marine, it assumes a yellow colour, as Mr. *Woulfe* first observed. *Phil. Transf.* 1779, p. 26.

When heated it bursts, becomes reddish, melts very difficultly *per se*; nay, according to Mr. *Bergman*, it is infusible with the blow pipe, and not totally fusible even with the assistance of fixed alkali, but easily by [illegible] and without effervescence. It also easily [illegible] with its own weight of fluor.

Its constituent parts were discovered by Mr. *Bergman* and Mr. *Scheele*, nearly at the same time, but first published by Mr. *Scheele* in the Swedish Memoirs for 1781. It appears to contain about ½ its weight of calcareous Earth, and the remainder a peculiar acid of an earthy appearance, and iron.

This acid is separated from its earthy basis, by digesting the powdered stone in three times its weight of nitrous acid, and after pouring off this acid, and edulcorating the residuum, digesting it again in caustic volatile alkali, after some time the alkali is also poured off, and the residuum being edulcorated, is again digested in nitrous acid, and afterwards in volatile alkali: These successive digestions are continued until the greater part of the stone disappears, the nitrous acid constantly taking

taking up the calcareous Earth, and the volatile alkali uniting to the tungſten acid; at laſt the tungſten acid is precipitated from the volatile alkali in the form of a white powder, by ſaturating the alkali with any other acid. This powder is ſoluble in 20 times its weight of boiling water, and then reddens litmus, has an acid taſte, and with lime water produces a regenerated tungſten; its ſpecific gravity is about 3,600.

SPECIES V.

Mild Calcareous Earth mixed with a notable Proportion of Magneſia.

I. VARIETY.

Compound Spar.

This ſtone is deſcribed by Mr. *Woulfe. Phil. Tranſ.* 1779, p. 29. It is there ſaid to be either white and ſemitranſparent, or of a pearl colour, or reddiſh, or of different ſhades of brown or yellow, of a peculiar gloſs or brightneſs, like gold, braſs, or copper; and to conſiſt of flat, ſolid, and rhomboidal chryſtals, and harder than calcareous ſpars. It efferveſces with acids.

One hundred parts of it contain 60 of mild calcareous Earth, 35 of mild muriatic, and

5 of iron: the iron appears to be accidental, and its quantity greater or ſmaller, according to the colour of the ſtone.

II. Variety.

Creutzenwald Stone.

This ſtone is mentioned, but not deſcribed by Mr. *Bayen* 13 *Roz.* 59. It is probably of a brown, or yellowiſh colour, and great weight; it contains by Mr. *Bayen*'s account, 75 *per cent.* mild calcareous Earth, 12 mild magneſia, and 13 of iron. It is found near *Creutzenwald*, and there uſed as a flux for iron ores.

Species VI.

Mild Calcareous Earth mixed with a notable Proportion of Clay.

I. Variety.

In a looſe Form. Calcareous Marl.

Marl is well known from its uſe in agriculture. I diſtinguiſh two ſorts of it, the calcareous and the argillaceous; it is of various colours, grey, yellow, red, brown, or bluiſh; theſe ariſe from a mixture either of iron or pyrites. The calcareous ſtrongly effervesces

fervesces with acids; it is of different degrees of hardness, and readily bursts and falls into powder in water, or by exposure to the air. When the calcareous Earth is in large proportion it burns to lime, and even vitrifies in a stronger heat. The proportion of mild calcareous Earth is from 50 to 75 or 80 per cent. if greater it should rather be classed among chalks. Hence any Earth of this sort, that loses from 16 to 27 parts of its weight per cent. by solution in acids, may be deemed a calcareous marl, this being the weight of the volatilized fixed air which corresponds with the above proportion of calcareous Earth. Note also, that by *clay* I mean common clay, that is, a mixture of argill and siliceous Earth, in which this latter mostly predominates. See Dr. *Withering's* Dissertation. *Phil. Trans.* 1773, p. 161, and 3. *Edinb. Essays*, p. 4.

II. Variety.

In a Stony Form.

Travertino, Pietra Forte, Pietra Fongaia of the Italians. Margodes.

The two first differ only in hardness; they are of a grey, blue, or yellow colour; the first loose and porous, the second harder; the third is a tufa, which, containing the seeds of mushrooms, produces them yearly, on being sprinkled

ſprinkled with water. *Ferber Italy*, 117, 159. They are often formed of volcanic aſhes, indurated by water, and evidently contain ſome proportion of iron; the two firſt are uſed as lime ſtones. The *pietra colombina*, and *turchina*, are ſaid to be of this ſort.

Analogous to theſe is the *margodes*, a bluiſh grey ſtone, entirely reſembling clay in its outward appearance, but ſo hard as to cut ſpars, or even zeolytes, but not to ſuch a degree as to give fire with ſteel; dull in its fracture, its texture thick laminæ, and of a conchoidal form; its ſpecific gravity 2,877; it efferveſces with acids. I found it to contain 50 per cent. of calcareous Earth, about 32 of argill, 15 of ſilex, and 2 of iron.

Mr. *Bergman*, in his remarks on the mountains of *Weſt Gothland*, *Memoirs of Stockholm*, 1768, mentions a ſort of red marble found near *Roloock*, which contains ſo much clay that it hardens in fire, and even melts in a ſtrong heat.

Species VII.

Mild Calcareous Earth mixed with a notable Proportion of Ponderous Earth.

Barytical Limeſtone, or Marl.

This is ſaid to be found both in a ſtony and looſe form in *Derbyſhire*; the former is ſaid

ſaid to be of a grey colour, and heavier than common lime-ſtones, but I have ſeen none of them.

SPECIES VIII.

Mild Calcareous Earth mixed with a notable Proportion of Siliceous Earth.

I. VARIETY.

Stellated Spar, Stern Spath, Stern Schoerl of the Germans.

This is opake, and of a radiated form, found in limeſtone by Mr. *Fichtel* on the *Carpathian Mountains*. It effervеſces with acids, and according to Mr. *Bindheim*, 100 parts of it contain 66 mild calcareous Earth, 30 of ſiliceous, and 3 of iron. 3 *Schrift. Naturforſch. Freunde*, p. 454.

II. VARIETY.

Calcareous Grit, Calcareous Sand-ſtone, Calcarius Arenarius, Pierre de Taille Calcaire, Moellon, Pierre de Liais. Monnet Mineralogie, p. 216.

Its colour is various, but moſtly white, grey, brown, or of different ſhades of yellow: it effervеſces with acids, and is more or leſs ſoluble in them, according to the proportion

portion of mild calcareous Earth, which alſo varies, from 50 to 70 or 80 per cent. when leſs, it ſhould be reckoned among the ſiliceous ſand-ſtones.

It frequently contains alſo a ſmall proportion of argill, and a ſtill ſmaller of iron. Its ſurface is generally rough; its texture moſtly granular, but ſometimes ſcaly: it does not ſtrike fire with ſteel; it is ſometimes uſed as a limeſtone; it hardens by expoſure to the air; it is frequently ſprinkled over with mica, but not in ſuch proportion as to alter its genus or ſpecies. The ſand-ſtone of *St. Helena*, which is very brittle, and burns to lime, is of this ſpecies.

Species IX.

Mild Calcareous Earth mixed with Petrol in ſmall Proportion.

Swine-ſtone, Pierre Puante, Stinkſteine, Lapis Suillus, Orſten of the Swedes.

The colour of this ſtone is either white, grey, yellowiſh, brown, or black, with glittering particles; its texture granular, ſcaly, or lamellar; its form either round or priſmatic, and polygon or amorphous; its grain compact and equable, or looſe and open; its ſpecific gravity conſequently from two to three;

three; its hardneſs not ſo great as to give fire with ſteel.

It is ſoluble with effervеſcence in acids, but its moſt diſtinctive character is the offenſive urinous ſmell it gives when rubbed: it loſes this ſmell when heated ſufficiently, and gives a ſlight flame when ſurrounded with burning coals, and at laſt burns to lime.

It affords little or no oil by diſtillation.

It frequently contains a little argillaceous Earth and Iron, and moulders by expoſure to the air.

SPECIES X.

Mild Calcareous Earth mixed with a notable Proportion of Pyrites.

Pyritaceous Limeſtone, Pierre de St. Ambroix.

This ſtone was analyſed by Baron *Servieres*, 21 *Roz.* 394. 22 *Roz.* 207. Its colour is iron grey, interſperſed with ſhining particles. Its texture compact; its hardneſs ſuch as ſcarcely to give fire with ſteel; its ſpecific gravity 2,7034.

It is ſoluble in acids, and moſtly with effer-veſcence.

It

It calcines in a ſtrong heat, and makes nitre ſlightly detonnate. If diſtilled, it affords a ſmall portion of vitriolic acid, and ſome ſulphur ſublimes.

It conſiſts of about 75 per cent. mild calcareous Earth, and 25 of pyrites, which contains 14 of argill, 7 of quartz and ſulphur, and 4 of iron.

Species XI.

Mixed with a notable Proportion of Iron.

I. Variety.

Mild Calcareous Earth mixed with Iron.

Theſe ſtones are either yellowiſh white, or red: the former are of a ſcaly texture, and grow black when expoſed to the air, very weighty, efferveſce with acids, and contain about 25 per cent. of iron; the latter are of a coarſe grain, ſlightly efferveſce with acids, loſe 30 per cent. by calcination, and contain 10 per cent. of iron. Some ſtalactites alſo contain from 20 to 27 per cent. of iron. *Rinman Mem. Stock.* 1754. Other iron ſtones of this ſpecies, containing more iron, belong to the calcareous iron ores.

II. Variety.

Tungſten intimately mixed with Iron.

Red or Fleſh-coloured Tungſten.

It does not efferveſce with acids, ſcarcely gives fire with ſteel; is of a coarſe texture, eaſily pulverized: its ſpecific gravity from 4,9 to 5,8; becomes magnetic after calcination; eaſily melted with its own weight of fluor; with great difficulty affords about 30 per cent. of iron. *Cronſted. Mem. Stock.* 1751. Hence it is never uſed as an iron ore.

Compound Species, in which the Calcareous Genus predominates.

Species I.

Compounds of the different ſimple Species of the Calcareous Genus:

Here I place all the different compounds of mild calcareous Earth and gypſum, or fluor, or tungſten, &c. which may occur; alſo thoſe of gypſum and fluor, gypſum and tungſten, or fluor and tungſten, &c. which may be placed as varieties of this compound ſpecies.

Species II.

Species II.

Compounds of Calcareous and Barytical Species.

I have ſeen yellowiſh ſtones of this ſpecies from *Derbyſhire*, conſiſting of lumps of chalk interſperſed with nodules of baroſelenite: many more may occur, as compounds of gypſum and baroſelenite, fluor and baroſelenite, &c.

Species III.

Compounds of the Calcareous and Muriatic Species.

Under this head I range all the compounds of mild calcareous Earth, or fluor, or gypſum, which contain ſteatites, ſerpentine, talc, amianthus or aſbeſtos. Of this ſpecies the following varieties have been obſerved.

I. Variety.

White Marble interſperſed with Spots of Steatites, or Soaprock Kolmord Marble. Cronſted. § 261.

This is of a ſcaly texture, and the ſteatites and ſoaprock either green or black.

II. Variety.

II. VARIETY.

1. *Pietra Talchina.*

This consists of white spar, with veins of talc.

2. *Verde Antico.*

A light green marble, with deep green, black, white, and purple spots; 100 parts of it contain, according to Mr. *Bayen*, 62 mild calcareous Earth, 30 of green talc, 1 of magnesia, and 1 of semiphlogisticated iron. 12 *Roz.* 56.

SPECIES IV.

Compounds of the Calcareous and Argillaceous Species.

I. VARIETY.

Mild Calcareous Earth and Argillaceous Shistus.

1. *Green Campan from the Pyrenees.*

This is a marble of a green colour, and slightly magnetic. According to Mr. *Bayen*, 100 parts of it contain 65 of mild calcareous Earth, 32 of argillaceous, and 3 of semiphlogisticated iron, 11 *Roz.* 499. Since this

ſtone is ſomething magnetic, it is plain that the ſhiſtus muſt contain at leaſt 10 parts iron; and alſo, that this iron is not much dephlogiſticated. Hence alſo, the colour is green, which colour, or blue, is always, when it proceeds from iron, a ſign that the iron is not much dephlogiſticated; on the contrary, a red or yellow colour from iron, denotes it to be in a dephlogiſticated ſtate.

2. *Red Campan.*

A red marble, not magnetic; 100 parts of it contain 82 of mild calcareous Earth, 11 of argillaceous ſhiſtus, and 7 of dephlogiſticated iron. 11 *Roz.* 501.

3. *Yellow figured Marble from Florence.*

Mr. *Bayen* found 100 parts of it to contain 75 of mild calcareous Earth, 13 or 14 of ſhiſtus, and 4 or 5 of dephlogiſticated iron.

4. *Griotte.*

A red marble from *Autun*; contains 67 of mild calcareous Earth, 26 of reddiſh ſhiſtus, 2 of iron, and 1 of magneſia, per cent. according to Mr. *Bayen.*

5. *Amandola.*

5. *Amandola.*

A green honeycomb-like looking marble, containing white ſpots: 100 parts of it contain 76 of mild calcareous Earth, 20 of ſhiſtus, 2 of ſemiphlogiſticated iron; the cellular appearance proceeds the ſhiſtus. 12 *Roz.* 56.

6. *Cipolin from Rome.*

A green marble, with white zones. It gives fire with ſteel, though difficultly; 100 parts of it contain 67,8 of mild calcareous Earth, 25 of quartz, 8 of ſhiſtus, 0,2 of iron, beſides the iron contained in the ſhiſtus. 22 *Roz.* 52.

II. Variety.

Calcareous Earth and Mica.

1. *Cipolin from Autun.*

A green marble, conſiſting of 83 parts mild calcareous Earth, 12 of green mica, and 1 of iron. 12 *Roz.* 55.

2. *Micaceous Limeſtone.*

This is of a glittering appearance, of various degrees of hardneſs, and efferveſces

with acids; the proportion of mica is various. The *macigno* of the Italians is of this ſpecies. *Ferber*, 116. The yellow ſort is called *pietra bigia*, the blue *pietra colombina*, or *turchina*.

Species V.

Compounds of the Calcareous and Siliceous Species.

I. Variety. *With Quartz.*

1. *Calcareous Quartz and Puddingſtone.*

This conſiſts of lumps of quartz, and ſometimes felt ſpar, in a calcareous cement.

2. *Limeſtone with Veins of Quartz, Saxum Sahlbergenſe.*

Alſo ſeveral marbles in *Sweden* and *Siberia*, that ſtrike fire with ſteel.

II. Variety. *With Lava.*

1. *Calcareous Volcanic Puddingſtone, Cierchina.*

In this, lumps of ſpar and lava are found in a calcareous cement. *Ferber Italy*, 115.

2. *Marble mixed with Veins of black or green Lava. Ferber Italy*, 67.

Species VI.

Species VI.

Compounds of Calcareous Earths with Species of two or more Genera.

I. Variety.

Calcareous Porphyry.

This consists of quartz, felt spar, and mica, in separate grains, united by a calcareous cement.

II. Variety.

Limestone interspersed with Shoerl and Mica.

CHAP. IV.

Barytic Genus.

Species I.

Ponderous Earth combined with the Aerial Acid, aerated Baroselenite.

Dr. *Withering* presented me with a very pure specimen of this species from *Alston Moor*, in *Cumberland*. It much resembles alum, but its texture is striated: its specific gravity is 4,331, though when this compound is artificial its specific gravity is only 3,773, according to Mr. *Bergman*; evidently because it contains much water,

for 100 parts of it contain 65 of pure Earth, 28 of water, and 7 of the aerial acid; whereas 100 parts of the native contain about 20 of aerial acid and 78 of Earth, a little of the vitriolic baroſelenite, and no water. It effervesces with acids.

The artificial, when calcined, burns to lime, which has the properties of pure baroſelenite already deſcribed; but the natural will not burn to lime, for it will not part with its fixed air, but rather melts, as Dr. *Withering* has diſcovered. He alſo found that cauſtic alkalis precipitate this Earth from the nitrous and marine acids, which happens, as I think, from their taking up the exceſs of acid requiſite to keep it in ſolution.

Species II.

Combined with the vitriolic Acid.

Baroſelenite, Marmor Metallicum, Cronſt. 182, *Lapis Bononienſis, Selenitic Spar, Gypſum Spathoſum, Spathum Fuſibile, Margraf* 2, *Theile* p. 44, *Weigel Obſerv. Mineral.* p. 65 *and* 66. *Cawk, Petunſe of ſome, Ponderous Spar.*

This ſtone is of a white, grey, or yellowiſh white colour, and ſometimes reddiſh; ſometimes

times not harder than chalk, but moſtly very compact, and of a ſtony hardneſs, though never ſo hard as to give fire with ſteel. Its texture lamellar or fibrous; its ſhape either amorphous, orbicular, tabular, or criſtated, that is, jagged like a cock's comb, or chryſtalized in polygon priſms: it is alſo found opake, ſemi-tranſparent, or tranſparent; this laſt ſort is an electric *per ſe*.

Its ſpecific gravity is generally from 4 to 4,6, though ſometimes, as Mr. *Wiegleb* remarks, it is not ſo great. 11 *Nev. Endeck*, 15.

It is inſoluble, or nearly ſo, in water, as well as in acids.

The harder ſorts decrepitate in fire; it does not burn to Plaſter of Paris as gypſum does; it is infuſible *per ſe* with a blow-pipe, yet Mr. *D'Arcet* found the ſemi-tranſparent ſort fuſible in a long continued porcelain heat. 22 *Roz.* 26; probably becauſe it was placed in an argillaceous veſſel: but it is fuſible by the help of the mineral alkali, with efferveſcence, and alſo with borax and microcoſmic ſalt, according to Mr. *Bergman*.

It is often mixed with calcareous Earth. 6 *Roz.* 222. 13 *Roz. Supplement*, p. 408.

Mr. *Morveau* obſerves that it accompanies the ores of moſt metals. Mr. *Margraaf* alſo frequently found maſſes of it mixed with gypſum. 1 *Margr.* 332.

The eaſieſt method of decompoſing it, is that practiſed by Mr. *Wolfe* and Mr. *Wiegleb*, viz. by calcining it in a ſtrong red heat for 1 or 2 hours, with 1 ½ or twice its weight of fixed alkali; the neutral ſalt and ſuperfluous alkali are then waſhed of, and the Earth is found combined with fixed air. Mr. *Morveau's* method is cheaper. He calcines the ponderous ſpar with $\frac{1}{6}$ of its weight of charcoal for 1 hour, in a crucible, well luted, and a ſtrong red heat: he then diſſolves the Earth in the acetous acid. The ſulphur is thus ſeparated. *Mem. Dijon*, 1782. Mr. *Margraaf* decompoſed it in the liquid way, by mixing two parts of the ſtone with one of fixed alkali; then pouring hot water on it, and keeping it boiling for ſome hours. 1 *Margr.* 366. The decompoſed part, well edulcorated, is ſoluble in acids.

This ſpecies often forms the ſtony matter of petrifactions. *Mem. Dijon*, 1782. 1 *Semeſt.* p. 163.

According to Mr. *Bergman*, 100 parts of it contain 84 of Earth, 13 of the moſt concentrated

centrated acid, and 3 of water. 100 parts of artificial baroſelenite contain about 33 of vitriolic acid and water, and 67 of Earth.

Some ſpecies, particularly the red, contain 1 or two gr. of iron per cent.

SPECIES III.

Combined with the Sparry Acid.

This combination has not yet been found in nature; that formed by art is nearly inſoluble in water.

SPECIES IV.

Combined with the Tungſten Acid.

This combination is alſo inſoluble in water, but it has not as yet been found.

SPECIES V.

Mild Barytes intimately mixed with a notable Proportion of Silex and Iron.

I mention this ſpecies on the authority of Mr. *Bindheim*. 4 *Berlin Schrift*. 397. It is inſoluble in acids, and of a ſparry texture; but, as he ſays it becomes ſoluble after calcination with oil, I ſhould be inclined to judge it rather a baroſelenite.

SPECIES VI.

SPECIES VI.

Baroſelenite mixed with a notable Proportion of Silex, Mineral Oil and Terrene Salts, Liver Stone, Lapis Hepaticus.

It's colour is white, grey, yellow, brown, or black; it is generally compact, but not ſo hard as to give fire with ſteel; its texture is either equable or laminar, ſcaly or ſparry, and it takes a poliſh as alabaſter.

It does not effervеſce with acids.

When calcined, it is partially reduced to a ſort of Plaiſter of Paris.

It emits a ſmell of hepar ſulphuris, at leaſt when rubbed.

According to Mr. *Bergman*, 100 parts of it afford 33 of baroſelenite, 38 of ſilex, 22 of alum, 7 of gypſum, and 5 of mineral oil. The increaſe proceeds from the water of chryſtalization.

CHAP. VI.

Muriatic Genus.

Under this genus I include not only thoſe Earths and Stones in which magneſia predominates, but alſo thoſe in which the ſiliceous genus

genus predominates, if magnesia be, next to the siliceous, the most copious ingredient, and the compound possesses the characters of the muriatic, and not those of the siliceous genus.

Species I.

Combined with the Aerial Acid, and barely mixed with other Earths, in an earthy, or semi-indurated Form.

Pure magnesia has no where yet been found, nor even magnesia, barely combined with fixed air, and free from all mixture of other Earths. When combined with fixed air by art, 100 patts of it contain at a medium 30 of aerial acid, 48 of mere Earth, and 22 of water; but these proportions are variable within certain limits, the fixed air being found in the proportion of from 25 to 37, the Earth from 40 to 48, and the water from 20 to 30. in general when the proportion of fixed air is greatest, that of water is smallest, and *vice versa*.

I. Variety.

Mixed with Siliceous Earth.

Spuma Maris, Meerschaum of the Germans. Keffekill.

This is found in various parts of the world, particularly in the East, in veins of moderate thickness,

thicknefs, and is the fubftance of which the large Turkey tobacco-pipes are formed: it is probably found alfo in *North America*, being the fubftance called in *Canada*, *Terre a chalumeau.* It is of a white or yellow colour, foapy feel, and moderately hard. It hardens eafily in fire without requiring a great heat. In the ftate in which we receive it, that is baked, it does not effervefce with acids, and is difficultly foluble therein.

According to Mr. *Wiegleb's* analyfis, it confifts of equal parts, magnefia and filex. 5 *Crell. Nev. Entdeck*, p. 3.

II. Variety.

Mixed with Calcareous Earth and Iron.

It appears like an olive-coloured, or blue clay: the olive-coloured contains no argillaceous Earth: the blue fort contains moft calcareous Earth, alfo iron, a little argill, and petrefactions. Both are found near *Thionville.* The former fort is ufed in pottery. 13 *Roz.* p. 60.

III. Variety.

Mixed with Clay, Talc, and Iron.

This is a greenifh yellow, loofe Earth, of a greafy feel, found in *Silefia.* It contains

tains $\frac{1}{3}$ of its weight of magnesia. *Margraaf, 2 Theil.* p. 18.

Species II.

Combined with Aerial Acid, above four times its weight of Silex, and a smaller proportion of Argill.

I. Variety.

Steatites.

This is always of a green or greenish colour, and so soft as to be scraped by the nail; of a soft soapy feel: its texture undistinguishable; its specific gravity from 2,433 to 2,78. It is not easily diffusible in water, nor rendered ductile by mixture with it.

It does not effervesce with acids, and is very slowly and only partially soluble in the three mineral acids.

In fire it hardens, but is infusible *per se*, and becomes whiter. It is imperfectly melted by mineral alkali and microcosmic salt, but more perfectly by borax. It is apt to corrode the crucibles.

According

According to Mr. *Bergman's* analyſis, 100 parts of it contain 80 of ſilex, 17 of mild magneſia, 2 of argill, and nearly 1 of iron in a ſemiphlogiſticated ſtate.

II. Variety.

Soap-rock, Lapis Ollaris, Pot-ſtone, Speckſtein of the Germans, Spaniſh Chalk. 2 Margr. 14.

This is of a *yellow* colour, and ſometimes whitiſh, and but rarely black: it is alſo ſomewhat harder than the former variety, and probably the proportion of argill is ſomewhat greater, but in other reſpects it perfectly reſembles it. The black contains a mineral oil.

This ſtone is eaſily worked and turned, inſomuch that pots and mortars are often made of it.

Mr. *Gerhard* remarks, that the Swediſh *ſpeckſtein* often efferveſces with acids, and contains calcareous Earth, but that of *Saxony* and *Sileſia* never. The limeſtone is merely an accidental mixture. 4 *Berlin, Schriſt.* 300.

Species III.

Species III.

Mild Magnesia combined with Silex, Calcareous Earth, and a small proportion of Argill and Iron.

I. Variety.

Fibrous Asbestos, Alumen Plumosum.

The colour of this stone is generally greenish, and it consists of filaments either parallel to, or interwoven with each other. It is rough to the touch, and brittle and uneven in its fracture, hence it does not strike fire with steel. Its specific gravity is from 2,5 to 2,8.

It does not effervesce with acids, and is soluble in them but partially, and by particular management.

When sufficiently heated, it becomes somewhat whiter and more brittle, but is infusible *per se* by the blow-pipe, unless it contains a notable proportion of calx of iron. It is difficultly fusible with mineral alkali, more easily with borax and microcosmic salt, and with scarce any effervescence. It is never transparent, and in that respect, and in the uneveness of their fracture only, some sorts of

of martial aſbeſtos differ in external appearance from ſome ſorts of ſhoerl.

According to Mr. *Bergman*, this variety contains from 53 to 74 parts of ſilex, from 12 to 28 of mild magneſia, from 7 to 14 of mild calcareous Earth, from 2 to 6 of argill, and from 1 to 10 of iron *per cent.* 100 parts martial aſbeſtos contain 62 of ſilex, 13,7 of magneſia, 12 of calcareous Earth, 1,7 of argill, and 10,6 of iron; yet it gives in fuſion a white ſlagg.

II. Variety.

Coriaceous Aſbeſtos, Suber Montanum, Aluta Montana, Mountain Cork, Leather, &c.

This ſort of aſbeſtos reſembles in texture thoſe ſubſtances from which it borrows theſe fanciful appellations. It is eaſily diſtinguiſhed by its elaſticity and lightneſs, for it floats a long time on water. In other reſpects it reſembles the former ſpecies, except that its colour is either white, yellow, brown, green, or black.

100 parts of it contain from 56 to 62 of ſilex, from 22 to 26 of mild magneſia, from 10 to 12 of mild calcareous Earth, from 2 to 2,8 of argill, and about 3 of iron.

Species IV.

Species IV.

Mild Magnesia combined, with Silex, mild Calcareous Earth, Barytes, Argill and Iron.

Amianthus.

In structure this species resembles the first variety of the foregoing; consisting of long parallel fibres, in some degree flexible, and soft to the touch. The surface of its fracture is also uneven. Its colour, white, grey, greenish or reddish: its specific gravity 2,913.

It does not effervesce with acids, and is difficultly, and but partially soluble therein.

It is fusible *per se* in a strong heat, and also with borax, microcosmic salt, and mineral alkali, with effervescence. In fusion it again chrystalizes in filaments, but in a still stronger heat it forms a green glass, which corrodes the crucibles, as Mr. *Saussure* has observed.

100 parts of the *Amianthus* of *Tarentaise* examined by Mr. *Bergman*, afforded him 64 of silex, 18,6 of magnesia, 6,9 of calcareous Earth, 6 of barytes, 3,3 of argill, and 1,2 of iron.

Species V.

Pure Magnesia combined with something more than its own weight of Silex, about $\frac{1}{3}$ of its weight of argill, nearly $\frac{1}{3}$ of its weight of water, and about 1 or 2 tenths of its weight of Iron.

Serpentine, Lapis Nephriticus, Gabro of the Italians.

In respect to colour, as well as composition, this stone is susceptible of great variety, for it is found either white, green, brown, reddish brown, yellow, light blue, black, spotted, or streaked with veins of different colours. Its texture is either indistinct, obscurely laminar, or fibrous. It is harder than soap-rock, but not so hard as to give fire with steel, and less smooth to the touch, but susceptible of a good polish, looks like marble, and is often in thin pieces semi-transparent.

Its specific gravity is from 2,4 to 2,65.

It does not effervesce with acids, but is slowly and partially soluble in them.

It melts *per se* in a strong heat, and preys on the crucibles. *Vogel*, 103. In a lower degree of heat it hardens.

According

According to the analyſis of Mr. *Bayen*, 100 parts of it contain about 41 of ſilex, (which he takes rather to be mica) 33 of magneſia, 10 of argill, 12 of water, and about 3 of iron. The ſerpentine of Corſica contains a larger proportion of argill and a ſmaller of ſilex.

The greener ſorts of this ſtone have been called *nephritic.*

SPECIES VI.

Pure Magneſia intimately mixed with nearly twice its weight of Silex, and leſs than its own weight of Argill.

Venetian Talc.

Its colour is white, grey, yellowiſh, or greeniſh: it is ſoft and ſoapy to the touch, and in thin pieces ſemi-tranſparent: it is compoſed of very thin laminæ diſpoſed in a laminar or filamentous form, much tenderer and more brittle than thoſe of mica, but like this it has a metallic luſtre: its hardneſs is ſo inconſiderable that it may be ſcratched with the nail: its ſpecific gravity is 2,729.

It does not effervеſce with acids, and is ſoluble therein very difficultly by particular management, and only in part.

In fire it becomes more brittle and whiter, but is infuſible *per ſe* by the blow-pipe, and ſcarcely fuſible by fixed alkalis, but more completely, and with little effervеſcence, by borax or microcoſmic ſalt.

This talc contains ſomething leſs than 50 per cent. of ſilex, and about 2 per cent. of iron. The magneſia is in ſmaller quantity, but it exceeds the argill: the exact proportion I have not found.

Muſcovy talc conſiſts of broad, elaſtic, flexible, tranſparent leaves, and differs externally from mica only in being ſofter and more ſoapy to the touch.

SPECIES VII.

Combined with the Sparry Acid.

This combination is ſcarcely ſoluble in water, but has not yet been diſcovered in nature.

SPECIES VIII.

Combined with the Tungſten Acid.

This compound when artificial is alſo inſoluble, but has not as yet been obſerved native.

Compound

Compound Species in which the Muriatic Genus predominates.

SPECIES I.

Compounds of the different ſimple Muriatic Species with each other.

I. VARIETY.

1. Steatites mixed with Talc, *Craie de Briançon.* It is generally grey, yellow, or greeniſh: it ſeems more argillaceous than pure ſteatites, and contains more iron. Mr. *D'Arcet* found it fuſible in a porcelain heat.

II. VARIETY.

1. Serpentine mixed with veins or ſpots of green Steatites.

2. Red Serpentine mixed with veins of Aſbeſtos.

SPECIES II.

Compounds of the Muriatic and Calcareous Species.

1, Red, green, yellow, or black Serpentine, with veins or ſpots of white Calcareous Spar *Potzevera.* The black is called *Nero di prato*; the

the green *Verde di Suza*; but theſe names are not reſtrained to this ſpecies.

2. Serpentine with veins or ſpots of Gypſum.

SPECIES III.

Compounds of the Muriatic and Barytic Species.

I. VARIETY.

Serpentine with veins or ſpots of baroſelenite.

SPECIES IV.

Compounds of the Muriatic and Argillaceous Species.

I. VARIETY.

1. Steatites mixed with a notable proportion of indurated Clay. It is leſs ſoft to the touch, and ſomething harder than the pure ſteatites: its colour is grey or greeniſh brown: it frequently contains alſo mica or talc, and ſometimes a notable proportion of iron, and then it is red. The talcoſe is frequently called French chalk, or *Craie de Briançon.*

2. Steatites.

2. Steatites mixed with Shiſtus, or bituminous Shiſtus. This is blue or black, and rougher to the touch than pure ſteatites.

3. Serpentine mixed with veins or ſpots of Shiſtus.

4. Soap-rock mixed with Mica. *Cronſt.* § 265. Grey, yellow, or greeniſh.

SPECIES V.

Compounds of the Muriatic and Siliceous Species.

1. Serpentine with veins of Quartz or Feltſpar, or Shoerl.

CHAP. VII.

Argillaceous Genus.

SPECIES I.

Saturated with Aerial Acid.

Lac Lunæ.

This fanciful name was heretofore thought to denote a very fine ſpecies of calcareous Earth, but Mr. *Schreber* has lately ſhewn that the Earth to which this name is given, is a very uncommon ſpecies of argill. It is generally found in ſmall cakes of the

hardneſs of chalk, and like that, it marks white: its hardneſs is nearly as that of ſteatites, and does not feel as fat as common clay does: its ſpecific gravity is 1,669: its colour is ſnow white. When examined with a microſcope, it is found to conſiſt of ſmall tranſparent cryſtals; and by his experiments it plainly appears to be an argill ſaturated with fixed air. It efferveſces with acids, and contains a very ſmall proportion of calcareous Earth, and ſometimes of gypſum, and ſome feeble traces of iron. It is found near *Halles.* 15 *Naturforſch.* 209.

Species II.

Combined but not ſaturated with Aerial Acid, in a looſe or ſemi-indurated form, and mixed with fine Quartz or Silex in various proportions, a ſmall quantity of Water, and generally of Iron.

Clay, Creta of the Italians.

This ſpecies receives a number of different denominations, ariſing from its hardneſs, fuſibility or infuſibility, or the different uſes it is applied to, or relative to its colour, or origin; ſuch as ſtone clay or lithomarga, fuſible or apyrous clay, marl, Fuller's earth, pipe clay, kaolin, brick clay, umber, coloured clays, boles, pouzzolana, terras, tripoli, &c. All clays

clays are more or leſs eaſily diffuſible in water, which they imbibe with more or leſs avidity, according to their previous compactneſs, and if they contain much air they froth with water, burſt and fall to pieces: when they have imbibed it they are more or leſs ductil and vicid, according as the ſand they are mixed with is more or leſs fine. They contract in drying, and crack; when heated, they contract ſtill more, and harden to ſuch a degree as to give fire with ſteel. They do not effervеſce with acids, unleſs they contain magneſia or calcareous Earth. The finer clays have a ſmooth, and in ſome meaſure, a ſoapy feel.

Theſe are the properties of pure argillaceous Earths; yet moſt clays contain but from 25 to 48 per cent. of this Earth, the remainder conſiſts of fine ſiliceous Earth, and a little water. On the ſubtility and purity of the ſiliceous part, the fineneſs of clay principally depend.

Many clays contain a little volatile alkali, and ſome the vitriolic acid; probably this latter is united to the argill in the ſtate of embryon allum, that is, in ſuch proportion as not to render it ſoluble in water. Moſt of them contain alſo a ſmall proportion of iron.

Fuſible

Fusible Clays.

All clays, which, besides argillaceous and siliceous Earths, contain a mixture of calcareous or muriatic Earths, or gypsum, or fluor, or felt spar, or iron, are more or less fusible, according to the proportion of these foreign ingredients.

Apyrous Clays.

Clays that consist of argillaceous and siliceous Earths singly, without any mixture of iron or other metallic substance, or at least only in an inconsiderable proportion, are infusible. Such is that found near *Plombiere*, *Mem. Par.* 1778, p. 433.

Argillaceous Marl.

Any clay that contains from 20 to 50 per cent. of mild calcareous Earth, comes under this denomination. It differs prodigiously in point of hardness and colour: the hardest is called *lithomarga*, or stone marl. The best for agriculture is the grey or white; the coloured generally contain metallic particles: when it contains 20 or 30 per cent. of calcareous Earth it is fusible *per se*. The coloured marls, as they contain more iron, are still more

more fusible. This species of marl falls to pieces more difficultly, either in water or air, than calcareous marl.

Indurated marls, of a quadrangular form, have been called *Ludi helmontii*.

Fuller's Earth.

This is mostly of a white, grey, bluish, or yellowish colour, compact, semi-indurated, of a lamellar texture, and often conchoidal in its fracture; consisting of very fine particles, smooth and somewhat soapy to the touch: it bursts and is diffusible in water, with which it often froths like soap: it does not effervesce with acids; in a strong heat it melts into a slag. Microcosmic salt affects it but slightly; mineral alkali more powerfully, and with much effervescence, but borax melts it most completely.

Different specimens of it, from various countries, afforded Mr. *Bergman* from 47 to 60 of siliceous Earth, from 11 to 25 of argillaceous, from ½ to 6 parts of magnesia, from 3 to 7 of mild calcareous Earth, from 3 to 5,5 of dephlogisticated iron, and from 15 to 18 of water, mixed with a very minute proportion of marine acid; but this last was found only in a few of them. Its fulling power

power ariſes from the property of clay to abſorb oils, the fineneſs of its particles, which do not injure the cloth, and its eaſy diffuſibility in water, which renders it capable of being waſhed off.

Terra lemnia is a yellowiſh or fleſh-coloured clay of this ſort.

Pipe Clay.

Any moderately pure and fine white clay, which retains its colour in fire, is diſtinguiſhed by this appellation. That of *Cologne* is the pureſt, and is infuſible in the ſtrongeſt heat. Many of theſe clays become grey in a weak degree of heat, becauſe the mineral oil with which they are mixed burns to a coal, but in a ſtronger heat they again become white, this coal being conſumed.

Porcelain Earth, or Kaolin.

This differs from the former chiefly in the fineneſs or ſubtility of the ſiliceous ingredient. It ſometimes efferveſces with acids, either becauſe it contains cryſtalized argill, or magneſia, or calcareous Earth: it alſo abounds in talcoſe particles. It never contains any oily matter, and therefore retains its colour in every degree of heat.

Brick

Brick Clay.

Its colour is various, reddiſh, bluiſh, or yellowiſh: it always contains iron, and melts into a ſlag. The beſt ſort contains little or none of calcareous Earth, but a good deal of a coarſe ſiliceous ſand.

Coloured Clays.

Yellow, *red*, and *brown* clays contain moſt iron, ſometimes diſperſed through them, and ſometimes united to the ſiliceous part: in this caſe they are more difficultly fuſible. The yellow calx of iron is more dephlogiſticated than the red, and the red more ſo than the brown. When theſe clays contain about 14 or 15 per cent. of iron, they become magnetic after calcination.

Red chalk, *Rubrica fabrilis*, is, according to Mr. *Rinman*, either a clay intermixed with the red calx of iron, which hardens in fire, and then becomes magnetic and browner, and in a ſtronger heat melts into a black glaſs, and contains from 16 to 18 per cent. of iron, (but ſometimes it contains but 7 or 8 per cent. of iron, and then does not become magnetic by roaſting) or it is an impure ſteatites, mixed with clay and calx of iron. *Hiſtoria Ferri*, § 189.

Blue

Blue Clays.

These ſometimes loſe their colour and become white when heated, and conſequently contain but little of iron, but owe their colour to an oily matter, which is diſſipated by heat; others owe their colour, according to Mr. *Monnet*, to a mixture of pyrites. *Mineralogie*, p. 339. Mr. *Beaumé* ſays, that blue clays contain the vitriolic acid, but he probably found it only in the pyritical clays, for in other ſorts Mr. *Woulfe* could diſcover none. *Phil. Tranſ.* 1779, p. 20. Mr. *Bergman* found ſome which contained copper and a little of cobolt. *Rinman* mentions a blue lithomarga, which contained 13 per cent. of iron, 4 of lead, and ſome veſtiges of zinc. *Hiſt. Ferri*, § 201, p. 712.

Umber.

A brown or blackiſh ſubſtance, which ſtains the fingers, and is very light; it has long been taken for a clay, but Mr. *Hupſch*, *Mem. Berlin*, 1777, has diſcovered it to conſiſt of particles of decayed wood, mixed with bitumen; yet it is certain that this name hath alſo been given to a ſort of brown ochre, of the ſame colour, which becomes red when ſlightly heated, but in a ſtronger heat is again brown and magnetic, and in a ſtill ſtronger melts into a black glaſs. It does not efferveſce with acids before

before roasting, but after that the martial part is soluble.

Green Clays.

Some sorts are said to redden in fire, and contain iron. Mr. *Bergman* has found some which contain copper and cobalt; to separate which he precipitated the copper by iron, and digested the residuum in distilled vinegar. Other sorts are said to contain nickel.

Black Clays.

These are said to be bituminous.

Variegated.

The most remarkable of this species is the *Terra miraculosa Saxoniæ*, which is a beautiful indurated clay, of a purplish colour, with white, yellow, red, or brown veins or dots.

Bole.

Is a term of uncertain signification, and should therefore be banished. Some bestow this name on very smooth compact clays, consisting of the finest particles: others require besides, that their colour should be red, yellow, or brown, and that they should contain iron. The red generally blacken in fire, 2 *Bergm.*

Bergm. 476, yet do not become magnetic. *Rinman*, § 189. The yellow, when heated, become firſt red, and in a ſtrong heat, brown or black. *Calamita bianca* of the Italians is a white bole, ſtriated like aſbeſtos. *Ferber, Itally*, 122. *Terra ſigillata rubra* contains calcareous Earth, and becomes magnetic after torrefaction. *Rinman*, § 189.

Of Volcanic Origin.

Pouzzolana.

This is of a grey, brown, yellowiſh, or blackiſh colour, looſe, granular, or duſty, and rough, porous and ſpungy, reſembling a clay hardened in fire and then reduced to a groſs powder. It contains, mixed with it, various heterogenous ſubſtances: its ſpecific gravity is from 2,5 to 2,8, and it is in ſome degree magnetic: it ſcarcely effervesces with acids, though partially ſoluble in them: it melts eaſily *per ſe*: but its moſt diſtinguiſhing property is, that it hardens very ſuddenly when mixed with $\frac{2}{3}$ of its weight of lime and water, and forms a cement, which is more durable in water than any other. According to Mr. *Bergman's* analyſis, 100 parts of it contain from 55 to 60 of ſiliceous Earth, 19 or 20 of argillaceous, 5 or 6 of calcareous, and from 15 to 20 of iron. 3 *Bergm.* 193. It is evidently a martial argillaceous marl that

that has ſuffered a moderate heat. Its hardening power ariſes from the dry ſtate of the half-baked argillaceous particles, which makes them imbibe water very rapidly, and thus accelerates the deſication of the calcareous part; and alſo from the quantity and ſemi-phlogiſticated ſtate of the iron contained in it. It is found not only in *Italy* but alſo in *France*, in the provinces of *Auvergne* and *Limoges*, and alſo in *England*, and elſewhere.

Traaſs, or Terras.

This differs but little in its principles from pouzzolana, but is much more compact and harder, porous and ſpungy. It is generally of a whitiſh yellow colour, and contains more heterogenous particles, as ſpar, quartz, ſhoerl, &c. and ſomething more of calcareous Earth: it effervеſces with acids, is magnetic, and fuſible *per ſe*. When pulverized, it ſerves as a cement, like pouzzolana. It is found in *Germany* and *Sweden*.

Tuſa.

Volcanic aſhes concreted with various other ſpecies of ſtone, but in which argill predominates, forms the ſtone thus called: it is harder than traaſs, but ſtill porous and ſpungy.

White Volcanic Earth.

That of *Solfatera*, examined by Mr. *Bergman*, was found to consist chiefly of silex, mixed with about 4 per cent. of argill, and 8 per cent. of allum. 3 *Bergm.* 198.

Tripoli.

Its colour is either white, grey, yellow, reddish, or brown, either indurated and brittle, or loose, powdery, and rough: it does not soften in water, nor effervesce with acids. According to Mr. *D'Arcet*, it is vitrifiable *per se* in a porcelain heat long continued; and according to Mr. *Bergman*, it yields to borax and microcosmic salt, but scarcely to fixed alkali.

Mr. *Haase*, who has lately analysed it, found 100 parts of it to contain 90 of siliceous Earth, 7 of argill, and 3 of iron; but the red sort probably contains more iron. According to Mr. *Gerhard*, magnesia has sometimes been extracted from it.

It is evidently a volcanic product; for a coal mine near *St. Estienne* having accidentally taken fire, and the fire in its progress having extended to some strata of shistus and bitumen, tripoli was found in those parts of the strata that

that the fire had acted upon, but not in any other. *Mem. Par.* 1769, p. 276.

The *rotten ſtone* of *Derbyſhire* is, according to Mr. *Ferber*, a tripoli mixed with calcareous Earth.

SPECIES III.

Barely ſaturated with Vitriolic Acid.

Embryon Allum.

This ſpecies was firſt diſcovered by Mr. *Beaumè*; it forms ſmall ſcaly chryſtals like mica, which require 1450 times their weight of water to diſſolve them in the temperature of 60°. It is no where found ſingle, but generally mixed with clays, from which it may be ſeparated by boiling, and diſſolved in water, to which it gives an earthy taſte, and is ſeparable by the affuſion of lime water, which precipitates the argill.

SPECIES IV.

Barely ſaturated with Marine Acid.

Embryon Marine Allum.

As a ſolution of marine alum, completely ſaturated with argill, forms alſo a very diffi-

cultly ſoluble compound, and as many clays are found to contain the marine acid, it is probable that this ſpecies exiſts in them, though it hath not yet been noticed.

In a ſtony Form.

Under this head I comprehend all thoſe ſtones which, although the ſiliceous genus predominates in their compoſition, and the argillaceous, with reſpect to quantity, obtains only the ſecond place, yet do not poſſeſs the character of ſiliceous ſtones, as they do not ſtrike fire with ſteel; and on the contrary, I exclude thoſe which poſſeſs the characters of ſiliceous Earths, though they contain the argillaceous in greater quantity.

SPECIES V.

Argill combined with 1,36 *its weight of Silex,* 0,7 *of its weight of pure Magneſia, and* 0,5 *of its weight of highly dephlogiſticated Iron.*

Pure Mica.

This ſtone, in its pureſt ſtate, is colourleſs; but either from a leſs intimate combination, or from a mixture of ſome ſuperfluous ingredient, principally iron, it is found of different colours, white, red, yellow, green, brown, or black, (the white and yellow ſort have

have a ſplendid metallic appearance) ſmooth, but not greaſy to the touch, which diſtinguiſhes it from talc. Its texture is always lamellar or ſcaly, and the lamellæ, or ſcales, are ſlightly flexible and often elaſtic; theſe ſcales are ſometimes parallel to each other, ſometimes interwoven, ſometimes wavy, or undulated, and ſometimes they repreſent filaments. Its ſpecific gravity is from 2,535, to 3,000 when loaded with iron.

It does not efferveſce with acids, and is inſoluble in them without particular management, but after it has been calcined with 4 times its weight of fixed alkali, it efferveſces ſtrongly, and is in great meaſure ſoluble.

The pure colourleſs mica is infuſible *per ſe*, and ſcarcely melts even with mineral alkali, but yields more readily to borax or microcoſmic ſalt, with ſcarce any efferveſcence; but the coloured ſorts were found by Mr. *Sauſſure* to be fuſible *per ſe*, though with difficulty, for they require a ſtronger heat than ſhoerl does.

100 parts of the colourleſs kind contain 38 of ſilex, 28 of argill, 20 of magneſia, and 14 of the moſt dephlogiſticated calx of iron. Martial mica contains beſides, 10 or 12 per cent. of a more phlogiſticated

calx of iron, from whence its various colours are derived, and a proportionably ſmaller quantity of the other ingredients.

Argillaceous Fiſſile Stones.

Theſe and many other of different genera, have been comprehended under the denomination of *Schiſti*, but to avoid ambiguity, I think it expedient to confine this name to ſtones of the argillaceous genus.

SPECIES VI.

Roof Slate, Shiſtus Tegularis.

Of this ſpecies there are many varieties, none of which have been hitherto analyſed, except the bluiſh purple ſlate chiefly uſed here, which I have lately examined, and to which, as to a ſtandard, I ſhall refer the other ſorts.

I. VARIETY.

Argill intimately mixed with 1,77 *of its weight of Siliceous Earth,* 0,3 *of its weight of Magneſia,* 0,15 *of Calcareous Earth, both ſlightly aerated, and nearly* 0,54 *of its weight of Iron, beſides a ſlight admixture of Mineral Oil.*

Bluiſh Purple Slate.

It does not ſtrike fire with ſteel, and may be ſlightly ſcraped with the nail: it is very brittle,

brittle, and of a lamellar texture: its ſpecific gravity is 2,876: when in pieces of ⅛ of an inch thick, or leſs, it gives a clear ſound if ſtruck: its grain is moderately fine: it is never tranſparent: it ſlightly effervesces with acids when reduced to powder, otherwiſe not: when heated red, it loſes ſomething more than 2 per cent. of its weight, ſlightly detonnates with nitre, and then aſſumes a browniſh red colour, but calcination does not render it magnetic: in a ſtronger heat it is fuſible *per ſe*, and forms a black ſcoria: it is difficultly diſſolved by mineral alkali in the dry way, more eaſily by borax, though with little effervefcence, and alſo by microcoſmic ſalt with ſome effervefcence. Mr. *Gerhard* remarks, that it melts with equal eaſe in chalk or clay veſſels.

Dephlogiſticated ſpirit of nitre, after ſtanding on it two months in cold, aſſumes a green colour.

I found 100 gr. of it to contain about 46 of ſilex, 26 of argill, 8 of magneſia, 4 of calcareous Earth, and 14 of iron. Part of the iron ſeems to be in a phlogiſticated ſtate, from its union with the oil, and part in a dephlogiſticated ſtate, or that of a red calx. This is united to the argillaceous part and ſilex, and is very difficultly ſeparated.

 II. VARIETY.

II. VARIETY.

Pale, ſlightly Purple, or bluiſh Shiſtus.

This ſtone is harder than the foregoing, its laminæ thicker, and its texture coarſer: it ſeems to contain a larger proportion of the ſiliceous and a ſmaller of the martial ingredient.

III. VARIETY.

Blue Shiſtus.

The proportion of the earthy ingredients being the ſame as in the firſt variety, that of the martial ingredient ſeems to be ſmaller.

Other ſtones are alſo uſed for covering houſes in various countries, but they are eaſily diſtinguiſhed; as their laminæ are much thicker, their ſurface more uneven, and their texture coarſer. They chiefly belong to the claſs of ſand-ſtones, or to the calcareous genus.

IV. VARIETY.

Dark Blue Slate, Shiſtus Scriptorius.

It effervesces more briſkly with acids, and ſeems to contain more magneſia, and leſs iron, than

than the firſt variety: its ſpecific gravity is 2,701.

SPECIES VII.

Argillaceous Earth mixed with a variable Proportion of Pyrites, with a little Magneſia and Calcareous Earth.

Pyritaceous Shiſtus.

Its colour is grey, brown, blue, or black: it is more or leſs decompoſable by expoſure to the air, according to the quantity of the pyritous ingredient and the ſtate of the iron in the pyrites: if the iron be in a ſemiphlogiſticated ſtate it is eaſily decompoſed, but if the calx of iron be already much dephlogiſticated, it will be decompoſed but ſlowly, if at all. *Aluminous ſchiſtus* is of this ſpecies, but will more properly be mentioned in treating of alum.

SPECIES VIII.

Slate, or Pyritaceous Shiſtus, intimately mixed with a notable Proportion of Mineral Oil or Bitumen.

Bituminous Schiſtus.

It is generally black, of a lamellar texture, of different degrees of hardneſs, but never gives

gives fire with ſteel: it emits a ſtrong ſmell when heated, and ſometimes without heat; does not ſhew white when ſcraped.

Species IX.

Argill mixed with from 3 to 4 tenths of its weight of Silex, and a little of the yellow or red Calx of Iron.

I. Variety.

Argillaceous Shiſtus, Flag-ſtone.

This is of a grey, yellowiſh, or reddiſh white colour; does not give fire with ſteel, nor efferveſce with acids: its ſpecific gravity is from 2,6 to 2,78: it is in ſome places uſed for covering of houſes, but moſtly for flooring: it is ſometimes compact, and ſometimes ſandy, like the next variety, and then its ſpecific gravity is ſmaller.

II. Variety.

Argillaceous Grit, Free-ſtone, or Sand-ſtone.

It is called free-ſtone becauſe it may be cut eaſily in all directions: its texture is more or leſs porous, equable and rough to the touch: it exhales an earthy ſmell when freſh broken and breathed upon: it does not give fire with ſteel, nor efferveſce with acids.

That

That from *Hollington*, near *Utoxeter*, is of a whitiſh or yellowiſh grey, and its ſpecific gravity 2,288. That from *Kniperſly*, in *Staffordſhire*, is of a bluiſh grey, and ſo infuſible as to be uſed for a fire-ſtone: its ſpecific gravity is 2,568.

SPECIES X.

Argillaceous Earth intimately mixed with 1,7 of its weight of Silex, about 0,7 of its weight of mild Magneſia, 0,09 of its weight of mild Calcareous Earth, and about its own weight of ſemiphlogiſticated Calx of Iron.

Horn-ſtone, Hornblende of Cronſted, and Talcum Striatum of Rinman, Mem. Stockh. 1754.

The general characters of this ſtone, beſides a partial ſolubility (though without efferveſcence) in acids, and a hardneſs never ſufficient to ſtrike fire with ſteel, properties which are common to it with the former ſpecies,) are 1ſt. a ſpecific gravity never leſs than 2,66, and frequently riſing to 3,88. 2d. a ſtrong earthy ſmell which it exhales on being breathed upon, or having hot water poured on it: 3d. a toughneſs or viſcidity perceived in pounding it in a mortar, like mica or horn, from whence it derived its name: 4th. its affording a greeniſh grey powder when pounded:

ed; 5th. fusibility *per se*, as it is said, though I could not melt it with the blow-pipe. It is frequently mixed with pyrites.

I. VARIETY.

Black Horn-stone, Corneus Nitens Waller, Sp. 169.

Its texture is lamellar or granular; the former is sometimes so soft as to be scraped with the nail; its surface frequently as glossy as if it had been greased: its specific gravity is from 3,6 to 3,88; it possesses besides all the specific properties above-mentioned in a high degree: it does not detonate with nitre: it becomes of a snuff colour when heated, and then slightly effervesces with diluted nitrous acid: its solution in this acid is of a greenish colour.

In order to discover the principle on which its smell depends, I boiled its powder in water, but did not find the water altered in taste, nor did any test I applied shew any change in it.

I found 100 gr. of the lamellar sort to contain 37 of silex, 22 of argill, 16 of magnesia, 2 of calcareous Earth, (both in a mild state) and 23 of calx of iron, not much dephlogisticated.

II. VARIETY.

II. Variety.

Greenifh Grey Horn-ftone.

This is of a granular texture, or ftriated; the fpecific gravity of the pureft fpecimen I examined is 2,683: it is not fo foft as the fofteft of the former variety.

I fufpect the common pale greenifh grey whetftone to be of this fpecies: it is of a clofe granular texture, exhales an earthy fmell, affords a greenifh powder, does not effervefce with acids, nor give fire with fteel; its fpecific gravity is 2,664; it contains 65 per cent. of filex.

III. Variety.

Killas.

This ftone is chiefly found in *Cornwall*; its colour is pale grey or greenifh grey; its texture either lamellar or coarfely granular: the lamellar is fofter and lefs martial than the roof fhiftus: its fpecific gravity from 2,63 to 2,666.

I found 100 grains of the lamellar fort to contain about 60 of filex, 25 of argill, 9 of magnefia,

magnesia, and 6 of iron. The greenish sort contains more iron and gives a greenish colour to the nitrous acid.

Species XI.

Argillaceous Earth intimately mixed with 4 times its weight of Siliceous, ½ its weight of pure Calcareous, and something more than its weight of Iron.

Toad-stone.

Dr. *Withering*, who has given us an analysis of this stone, describes it as being of a dark brownish grey colour, of a granular texture, not giving fire with steel, nor effervescing with acids: it has cavities filled with chrystalized spar: it is fusible *per se* in a strong heat. *Phil. Trans.* 1782, p. 333.

100 parts of it contain 63 of siliceous Earth, 14 of argillaceous, 7 of calcareous, and 16 of dephlogisticated iron: it differs but little from basaltes; it is softer, contains a smaller proportion of iron, and a larger of silex.

Species XII.

Argill united to 2,3, or 8 times its weight of Silex, about half its weight of pure Calcareous Earth, and from once to twice its weight of Water, without any Iron, except accidentally.

Zeolyte.

This ſtone is found of different degrees of tranſparency, or perfectly opake, either colourleſs, whitiſh, yellowiſh, greeniſh, or reddiſh; its ſhape is either pyramidical, columnar, tabular, oval, capillary, or amorphous; its texture either granular, ſcaly, or radiated; the filaments diverging as from a central point, or indiſtinguiſhable.

It does not give fire with ſteel.

Its ſpecific gravity is from 2,1 to 3,15, but this laſt is very rare.

It does not efferveſce with acids, though it is partially ſoluble in them, but if inſerted into a proper proportion of concentrated nitrous acid, it forms a gelatinous maſs, ariſing from the ſuſpenſion and diffuſion of the ſiliceous Earth contained in it; but this property is not peculiar to *zeolyte*, as Mr. *Pellatier* has ſhewn,

ſhewn. 20 *Roz.* 429. And ſome few zeolytes do not become gelatinous. 3 *Bergm.* 228.

When expoſed to a ſtrong heat it dilates and ſwells, more or leſs, according to the proportion of water contained in it, and afterwards melts *per ſe*, more or leſs eaſily, according to the proportion of calcareous Earth, into a frothy ſlag; in the moment of fuſion it is ſaid to become phoſphoreſcent; it alſo melts eaſily, and with effervefcence, with mineral alkali; ſomething more difficultly with borax, but microcoſmic ſalt has ſcarce any effect on it. When in fuſion, it ſcarcely injures the crucibles. 22 *Roz.* p. 29. This dilatibility is the ſureſt criterion whereby to diſtinguiſh zeolytes. The Upland zeolytes are difficultly fuſible.

According to Mr. *Bergman's* analyſis, the red zeolyte of *Adelfors* contains 80 per cent. of ſiliceous Earth, 9,5 of argillaceous, 6,5 of pure calcareous Earth, and 4 of water. *Van Troil's Letters*, p. 370.

The white, oval, radiated zeolyte of *Fero*, contains, according to Mr. *Pelletier*, 50 of ſilex, 20 of argill, 8 of pure calcareous Earth, and 22 of water. 20 *Roz.* 420. Mr. *Meyer* found another of the radiated ſort to contain

contain 58,33 per cent of ſilex, 17,5 of argill, 6,66 of lime, and 17,5 of water. 4 *Berlin Beſchaft.* p. 330. In general the cryſtalized ſorts contain more water than the amorphous. Mr. *Bergman* found the zeolyte of *Jemptland* to contain 16 per cent. of calcareous Earth, and that of *Fero* to contain 25 per cent. of argill, ſo that the proportions are very variable.

SPECIES XIII.

Of Volcanic Origin.

Argillaceous Earth imperfectly united to 4 times its weight of Siliceous, and $\frac{1}{3}$ *of its weight of Iron.*

Pitch-ſtone, Lava.

It is of a greyiſh, greeniſh, black, red, or brown colour, has the glaſſy appearance of a ſemi-vitrified ſubſtance, and melts eaſily *per ſe*: it often contains ſubſtances ſeemingly heterogenous: ſome pieces of it do not give fire with ſteel, and therefore belong to this genus, others do, and belong therefore to the ſiliceous genus.

According to Mr. *Wiegleb's* analyſis, 11 *Nev. Endeck*, p. 18, 100 parts of it contain

65 of ſilex, 16 of argill, 5 of iron, the remaining 14 gr. were diſſipated.

SPECIES XIV.

Argill mixed with a notable Proportion of red Calx of Iron, and ſometimes Steatites.

Red Chalk.

It hardens in fire, and then often becomes magnetic; in the ſtrongeſt heat it melts into a black glaſs, which does not corrode the crucibles, as calcareous ores do: it affords 16 or 18 per cent. of iron; if it does not become magnetic it affords only from 7 to 14 per cent. *Rinman Hiſtoria Ferri*, § 189.

Compound Species in which the Argillaceous Genus predominates.

SPECIES I.

Compounds of the different Species of the Argillaceous Genus.

I. VARIETY.

Micaceous Marl.

II. VARIETY.

Micaceous Shiſtus, either Slate or Flag-ſtone.

III. VARIETY.

III. Variety.

Micaceous Sand-ſtones.

IV. Variety.

Micaceous Horn-ſtone.

Green hornſtone mixed with mica. *Gronſtein* of *Cronſted*, § 267, frequently contains pyrites, and 20 per cent. of iron.

V. Variety.

Shiſtus and Argillaceous Grit mixed in various Proportions.

VI. Variety.

Shiſtus and Hornſtone mixed in various Proportions.

Species II.

Compounds of the Argillaceous and Calcareous Genus.

I. Variety.

Bituminous Shiſtus mixed with Limeſtone.

Marmore Nero Antico.

100 parts of this contain 18 of mild calcareous Earth, the remainder ſhiſtus, from

 which

which 18 parts of oil were extracted by distillation, also argill, and magnesia, and 6 parts of iron, besides much that was not separated. 12 *Roz.* 63.

Species III.

Compounds of the Argillaceous and Barytical Genus.

Species IV.

Compounds of the Argillaceous and Muriatic Genus.

I. Variety.

Shistus mixed with Steatites or Soap-rock.

II. Variety.

Shistus mixed with Serpentine.

III. Variety.

Hornstone mixed with Mica and Serpentine.

IV. Variety.

Hornstone mixed with Mica and Steatites, or Soap-rock.

V. Variety.

V. Variety.

Mica mixed with Soap-rock, Schneidestein.

When the mica prevails the texture is slaty.

Species V.

Compounds of the Argillaceous and Siliceous Genus, none of which gives Fire with Steel.

I. Variety.

1. *Mica mixed with Quartz, Stellstein, Cronst.* § 262

It is of a slaty texture and easily divided.

2. *Mica and Quartz, and a little Argill, Saxum Novaculum Linnei.*

II. Variety.

1. *Hornstone and Mica mixed with Quartz.*

2. *Hornstone and Shoerl.*

This is also called *Gronstein*, when the hornstone is green.

3. *Hornstone, Mica and Shoerl, Binda of the Swedes.*

It ſometimes contains alſo quartz and pyrites. Its ſpecific gravity exceeds 3,000.

III. Variety.

White Clay mixed with Mica and Quartz, and of no particular texture. Greiſs, of the Germans, or Growan of the Corniſh Miners.

When the texture is lamellar and the ſtone harder, it is called *Gneiſs.*

IV. Variety.

Sandſtone mixed with Mica, and Feltſpar.

Species VI.

Compounds of the Argillaceous with two or more Genera.

I. Variety.

Micaceous Porphyry.

This conſiſts of a greeniſh grey, micaceous ground, in which red feltſpar and greeniſh ſoap-rock are inſerted. *Sauſſure Voyage dans les Alpes*, p. 111, even the mica is not pure, he ſuſpects it contains hornſtone, p. 127.

II. Variety.

Hornſtone mixed with Veins of Spar and Quartz, Mentioned by Mr. *Sauſſure,* p. 120.

CHAP.

CHAP. VIII.

Siliceous Genus.

All the ſtones I place under this genus give fire with ſteel, except opals, and yellow carnelians; and none efferveſce with acids, except *Lapis Lazuli* in powder, Barſhoerl, martial muriatic ſpar, and Turky hone.

SPECIES I.

Quartz, Cryſtal.

The ſtones of this ſpecies are in general the pureſt of the ſiliceous genus, though moſt contain a ſlight mixture of other Earths; the moſt obvious diſtinction among them, ariſes from their tranſparency or opacity.

SERIES I.

Tranſparent Quartz, Cryſtal.

This is either *colourleſs* and cryſtalized in hexagonal pyramids, and then called *mountain cryſtal*, or in various other forms, or amorphous. Its ſpecific gravity is from 2,65 to 2,7; its texture lamellar and generally ſhattery, its appearance glaſſy; it cracks and loſes its tranſparency when heated; it poſſeſſes all the other properties of pure ſiliceous

 Earth.

Earth. Mr. *Bergman* has extracted from 100 parts of mountain cryſtal, about 6 of argill, and 1 of calcareous Earth. 2 *Bergm.* 112. So alſo has Mr. *Abilgaard. Denſk. Shrift.* 1781. Yet Mr. *Gerhard* ſays, that ſome are ſo pure as to contain neither. *Gerh. Beytrage*, 78 and 85. He alſo ſays that the amorphous cryſtals, though colourleſs, being long digeſted in acids, afforded when treated with pure pruſſian alkali, ſome traces of iron, *ibid.* 85.

The pureſt and moſt tranſparent of theſe cryſtals form the falſe diamond, called briſtal, or kerry ſtone, diamant d'*Alençon*, &c.

The coloured tranſparent cryſtals derive their tinge generally from metallic particles in exceeding ſmall proportion; they all looſe their colour when heated; theſe form the falſe Gems. The moſt remarkable are the *red*, from *Oran*, in *Barbary*; falſe rubies.

Yellow. From *Bohemia*; falſe topazes.

Green. Falſe emeralds and praſius.

Violet } From *Bohemia* and *Saxony*.
Blue. }

It is ſaid that brown cryſtals may be cleared by boiling them in tallow. 7. *Roz.* 360.

Mr.

Mr. *Bergman* has formed perfect cryſtals by diſſolving ſiliceous Earth in the ſparry acid, and ſuffering it to cryſtalize ſlowly. It is probable that nature forms them in a long courſe of time from a ſolution or diffuſion of this Earth in pure water, or water that holds a little argill or calcareous Earth which probably enable it to take up more of the ſiliceous Earth than it otherwiſe could. Perhaps the experiment which once ſucceeded with Mr. *Achard*, was owing to ſome ſuch cauſe.

SERIES II.

Opake Quartz, or Pebbles.

Thoſe are alſo cryſtalized, or amorphous, either white, grey, or yellowiſh, or tinged of other colours by metallic particles. The former are leſs pure than thoſe of the firſt ſeries, containing a larger proportion of argill, or at leaſt the argill is leſs perfectly united with the ſiliceous part. Their ſpecific gravity is from 2,4 to 2,7; their ſurface either rough, or ſmooth and ſhining, the laſt are called *fat quartz*: the texture either lamellar or granular; they crack like the former in fire, and become of a duller colour; when rubbed againſt each other they emit a phoſphoric ſmell. They are often found in round maſſes in the beds of rivers.

The

The Coloured Opake Quartz are either.

Black, being mixed with a large proportion of iron.

Red, according to *Cronſted* they contain copper, but Mr. *Bergman* could find none in them. 2 *Bergm.* 430.

Blue, from *Uto* in *Sweden.*

Green, found at *Adelſdorf* in *Sweden*,

Series III.

Arenaceous Quartz or Sand.

Though the powdery ſtate of other ſtones does not deſerve any particular notice: yet that of quartz or ſilex does, from the great uſe that is made of it, and from its ſeeming to poſſeſs properties which are incompatible with it in a groſſer ſtate. It is of various colours and incapable of forming a maſs or hardening with water, the pureſt is white, the minute particles of which, when inſpected through a lens are tranſparent. It is ſeldom perfectly pure; Mr. *Achard* ſays that the fine white ſand of *Freyenwald*, which is uſed for the porcelain manufactories contains $\frac{1}{3}$ of its weight of argill and calcareous Earth, but this I ſhould rather take to be a petro-ſilex in

in powder. The finenefs of fome fpecies of fand is fo great as to pafs through fieves, that contain 10,000 vacuities in the fpace of an inch, as Mr. *Wedgewood* one of the moft celebrated manufacturers of earthen ware in Europe, has affured me. Hence this Earth has been found fufpended in fome waters in the quantity of 1 grain in a gallon. See 2 *Bergm.* 47, and *Cadet* in the Memoirs of the French Academy for 1767.

Species II.

Siliceous Earth intimately mixed and partly combined with about $\frac{1}{4}$ of its weight of Argill, and $\frac{1}{40}$ of its weight of Calcareous Earth.

Common Flint or Pebble, Hornftein, Kiefel of the Germans.

This ftone is found of all colours, or variegated with veins of different colours; it is commonly covered with an opake white cruft, which feems of the fame nature, but more imperfectly combined; this cruft adheres to the tongue like clay, yet ftrikes fire with fteel, fo that probably it contains a larger proportion of argill than the kernel. Flint is always femi-tranfparent in thin pieces; its hardnefs is various, though it always gives fire with fteel; its texture is folid, whereas,

whereas that of quartz is ſhattery; it breaks with ſmooth ſurfaces, one of which is convex, the other concave; it is never found cryſtalized, but rather in ſeparate irregular nodules, ſcattered through other ſtrata, and plentifully in *England* in beds of chalk; it has ſeldom any fiſſures, with which quartz abounds; its ſpecific gravity is from 2,65 to 2,700.

Flints are infuſible *per ſe* in the ſtrongeſt fire, but generally become white and brittle by reiterated calcination, which ſeems to indicate that they all contain a little water; and hence alſo, their decrepitation, when heated; The ſame may be ſaid of quartz; they are affected by fluxes in the ſame manner as the pureſt ſtones of this genus.

The common brown flint exhibited on Mr. *Wiegleb's* analyſis 80 per cent. of ſiliceous Earth, 18 of argill, and 2 of calcareous. 6 *N. Act. Natur. Curioſ.* p. 408. Coloured flints undoubtedly contain metallic particles.

To this ſpecies we muſt alſo annex the finer flints commonly called *Egyptian pebbles*, hæmachates, ſtigmites, ſilex ſardus. Theſe differ from common flints; 1[ſt.] in this, that they are leſs, if at all tranſparent; 2[d]. that their texture is finer, harder, and cloſer, and their

their ſpecific gravity greater; 3d. that they are always covered with an ochry cruſt; but they break with conchoidal ſurfaces, as flints do. Their colour is reddiſh, yellow, black, brown, or grey, or beautifully variegated. They probably contain metallic particles.

SPECIES III.

Siliceous Earth intimately mixed with from $\frac{1}{4}$ to $\frac{1}{3}$ of its weight of Argill, and from $\frac{1}{15}$ to $\frac{1}{12}$ of its weight of Calcareous.

Petro-ſilex, Chert.

This ſtone differs but little from the former in external appearance, only it is duller and leſs tranſparent; it is found of all colours, but generally dark blue, or yellowiſh grey; it breaks with conchoidal ſurfaces like the former, but is generally ſofter; it runs in veins through rocks, and hence derives its name; its ſpecific gravity is from 2,59 to 2,7: in fire it whitens and decrepitates like ſilex, but is generally more fuſible, for it commonly melts *per ſe*: it is not totally diſſolved in the dry way by mineral alkali, but borax and microcoſmic ſalt diſſolve it without efferveſcence.

From a reddiſh petro-ſilex uſed in the *Count de Lauragais* Porcelain Manufactory, and

and there called a felt-ſpar, I extracted 72 per cent. of ſilex, 22 of argill, and about 6 of mild calcareous Earth, but could not melt it by the blow-pipe. I believe the calcareous Earth was not in a mild ſtate in the ſtone. It ſhewed no ſign of iron notwithſtanding its ſlight reddiſh colour, nor of any other metal.

Species IV.

Siliceous Earth intimately mixed with about $\frac{1}{5}$ of its weight of Argill, and $\frac{1}{6}$ or $\frac{1}{7}$ of its weight of Calx of Iron.

Jaſper, Diaſpro of the Italians.

This ſpecies alſo borders on the former, but it has a ſtill duller, leſs glaſſy, and more earthy appearance in its fracture, and its granular texture is more diſtinct; it alſo often breaks with conchoidal ſurfaces; it is capable of a fine poliſh; its colour is generally reddiſh or green, or ſtriped; but it is alſo found blue, grey, or whitiſh; its ſpecific gravity is from 2,68 to 2,778, or more, when it contains more iron. In fire it retains its colour much longer than petro ſilex, never decrepitates, but grows rather harder, as Mr. *Wedgewood* aſſured me, and does not melt *per ſe* in clay crucibles, though it does in thoſe made of chalk. Alkalis borax and microcoſmic ſalt

ſalt affect it like the former ſpecies. Mr. *Gerhard* ſays that ſome ſorts of jaſper melt *per ſe*: theſe contain an over proportion of iron, or elſe calcareous Earth, and then form the link betwixt cherts and jaſpers.

The green jaſpers contain iron in a ſemi-phlogiſticated ſtate, and have often been confounded with malachites, but theſe latter never give fire with ſteel, to ſay nothing of the entire difference of their compoſition. Red jaſpers contain iron more dephlogiſticated.

Sinople is a dark red jaſper or flint, which ſtrikes fire with ſteel, and affords in the dry way 10 per cent. of iron, and melts into a black ſlag. *Rinm. Hiſt. Ferri*, § 189. If tried with the Pruſſian alkali, it would probably ſhew 18 or 20 parts of iron, as this always ſeparates nearly double the quantity of iron that can be extracted in the dry way.

Of the ſpontaneous Decompoſition of Stones by long Expoſure to the Air.

Flints, jaſpers, petro-ſilex, felt-ſpar, granites, lavas and ferruginous ſtones, have frequently been ſaid to be decompoſed by long expoſure to the air, and the obſervations of Mr. *Greville* and Sir *William Hamilton* have removed every doubt I entertained on this head.

With

With regard to ferruginous ſtones in which the calx of iron is not much dephlogiſticated, this decompoſition is eaſily underſtood, for this calx gradually becomes more dephlogiſticated by the action of water and air, attracts water and fixed air, and loſes its adherence with the ſiliceous or other ſtony particles: this is ſeen to happen to baſaltes, toadſtone, ferruginous limeſtone, &c. In other ſtones this decompoſition may ariſe from their containing calcareous Earth in a cauſtic ſtate, or manganeſe, for theſe will gradually attract water and fixed air, and then ſwell, burſt and looſen the whole texture of the ſtone, as we ſee happen to bricks that contain lime. Thus alſo glaſs is decompoſed by long expoſure to the air, the alkali attracting water and aerial acid. Mortar, on the contrary hardens by long expoſure to the air, becauſe, though the aerial acid be attracted, yet a great part of the water exhales.

Species V.

The finer Flints mixed with various Proportions of other Earths and Iron.

Precious Stones of the ſecond Order.

I. Variety.

Agates.

The oriental agate is almoſt tranſparent, and of a glaſſy appearance, but whitiſh, with inward

inward protuberances. The occidental is of various colours, and often veined with quartz or jaſper; it is moſtly found in ſmall pieces covered with a cruſt, and often running in veins through rocks, as flints and petro-ſilex, to which it is analogous, but more tranſparent, the Earths being better combined and the grain cloſer; its ſpecific gravity is 2,64; it often forms the ſtony matter of petrifactions.

Agates that preſent arboriſations are called mochoes.

Alkalis, borax and microcoſmic ſalt affect this ſtone in the ſame manner as they do flints.

II. Variety.

Opal, Oculus Mundi, Lapis Mutabilis.

This ſtone is of different colours, white, yellowiſh, or greeniſh brown; its peculiar characteriſtic is to reflect different colours, according to the different poſitions of the eye; it is moſtly of a ſpungy texture, and admits water into it, and generally too ſoft to ſtrike fire with ſteel; its ſpecific gravity is from 1,7 to 2,24.

The uſual fluxes act on it as on flints. Mr. *Bergman* has extracted argill from it.

Pſeudopal is opake, and reflects green and yellow rays, and hence called cat's eye.

Avanturine reſembles an opal with gold ſpecks, but is a product of art.

III. VARIETY.

Chalcedonian.

Its colour is a bluiſh cloudy white, or grey, with ſhades of other colours, and tranſverſely inſpected preſents an iris; when white and opake it is called *chachelong*: its ſpecific gravity, according to Mr. *Bergman*, is from 2,5 to 4,36. Stones of this latter weight muſt be very different from thoſe of the former. Theſe ſtones ſometimes contain water. It is affected by the uſual fluxes, as flint.

According to the experiments of Mr. *Bergman*, the chalcedony of *Fero* contains 84 per cent. of ſilex and 16 of argill. Mr. *Bindheim* found another ſort to contain 83,3 of ſilex, 11 of calcareous Earth, and 1,6 of argill, beſides a minute portion of iron. 3 *Schrift. Nuturfor. Freunde*, p. 429.

Opals and chalcedonies, which by admitting water within their pores become tranſparent, are called *hydrophanes*. This phœnomenon

nomenon is well explained in the ſecond volume of Mr. *Bergman's* works.

IV. Variety.

Onyx.

This is a very hard ſtone of the colour of the human nail, with ſtraight or circular zones of another colour; if the zones themſelves be of different colours, it is more eſteemed, and called *camehuya:* it is almoſt opake; its ſpecific gravity is from 2,5 to 2,6; it is affected by fluxes as the former varieties.

V. Variety.

Carnelian.

Its colour is of different ſhades of red; it is alſo of different degrees of tranſparency and hardneſs: the beſt is of an orange or yellow red, and gives fire with ſteel; the whitiſh or yellowiſh are too ſoft to give fire with ſteel, and leſs eſteemed; its ſpecific gravity is from 2,6 to 2,7; it loſes its colour in fire. Fluxes affect it like the above.

VI. Variety.

Sardonyx.

It conſiſts of chalcedony and carnelian, united either in zones, ſtrata, or ſpots.

Species VI.

Siliceous Earth perfectly united to, from an equal to 3 times its weight of Argill, and from $\frac{1}{6}$ to an equal weight of Calcareous Earth, together with from $\frac{1}{18}$ to an equal weight of Iron.

Precious Stones of the first Order.

I derive the denominations of theſe ſtones from their colour and hardneſs, and not from their hardneſs ſingly, as Jewellers moſtly do, as this property, though it contributes to their ſplendor and value, has but little or no connexion with their compoſition. I alſo omit many ſub-denominations of each ſort of theſe ſtones, which are to be found in treatiſes expreſsly written on that ſubject. The ſpecific gravity of all of them exceed 2,76, whereas that of coloured cryſtals never does. Their ſingular luſtre and tranſparency are well known.

I. Variety.

Red.

Ruby, Oriental.

It is commonly found cryſtalized in an octohedral form; its texture is foliated; its hardneſs

hardneſs much greater than that of any other ſtone, and yields only to that of diamond; its ſpecific gravity from 3,18 to 4,283.

In fire it is invitriable *per ſe*, and does not yield even to the focal rays of a burning glaſs, but a flame excited by dephlogiſticated air, directed by a blow-pipe, readily melts it; it does not loſe its colour in a heat that would melt iron. Borax and microcoſmic ſalt effect its fuſion, but mineral alkali fails.

100 parts of it contain, according to Mr. *Bergman*, 40 of argillaceous, 39 of ſiliceous, 9 of mild calcareous Earth, and 10 of iron.

Or, according to Mr. *Achard*, 41,66 of ſiliceous Earth, 36,66 of argill, 8,33 of calcareous Earth, and 10,83 of iron.

Brazil rubies are paler, and ſaid to be found in hexangular or polyangular cryſtals.

Jewellers, among whom hardneſs and tranſparency are the chief characteriſtics, mention alſo white and amethyſt coloured rubies, but theſe have not been analyſed.

Oriental rubies are chiefly found in *Pegu*, *Ceylon*, *Biſnagar*, and *Cambuya*. A baſer ſort

is found in *Finland, Bohemia, Silesia, Saxony* and *Hungary.*

II. Variety.

Yellow.

Topaz, Hyacinth.

Topas is of a gold colour; its texture foliaceous; its form cubic, parallelipedal, or prismatic; its specific gravity from 3,46 to 4,56; it loses its colour only in a very strong heat, and of the usual fluxes it yields only to borax and microcosmic salt.

According to Mr. *Bergman*, 100 parts of it contain 46 of argill, 39 of siliceous Earth, 8 mild calcareous, and 6 of iron. Its great specific gravity shews these Earths to be very perfectly united.

Oriental *hyacinth* is of a reddish yellow colour, generally crystalized in a prismatic form; in a strong heat it becomes paler, and according to Mr. *Achard*, may be melted in a wind furnace in 2 hours.

According to Mr. *Bergman*, 100 parts of it contain 40 of argill, 25 of silex, 20 of mild calcareous Earth, and 13 of iron; and according

according to Mr. *Achard*, 41,33 of argill, 21,66 of ſilex, 20 of calcareous Earth, and 13,33 of iron.

Hyacinths are found in *Poland*, *Bohemia*, and *Saxony*.

III. Variety.

Green.

Emerald, Chryſolite, Beryl.

The colour of emerald is pure green; it is ſometimes found in round flat pieces, but moſtly cryſtalized in hexagonal priſms; its ſpecific gravity is from 2,78 to 3,711. It is the ſofteſt of all the precious ſtones.

According to Mr. *Achard*, it preſerves its colour in a porcelain heat, and only becomes more opake; in a ſtronger heat it melts into a ſlag. *Mem. Stock.* 1768. Like the foregoing it eludes the force of mineral alkali, but yields to borax and microcoſmic ſalt. With the former, according to Mr. *Quiſt*, it gives a colourleſs glaſs.

100 parts of it contain, by Mr. *Bergman's* analyſis, 60 of argill, 24 of ſilex, 8 of calcareous Earth, and 6 of iron; and by that of

I 4 Mr.

Mr. *Achard*, 60 of argill, 21,66 of ſilex, 8,33 of calcareous Earth, and 5 of iron.

It was antiently found in *Egypt*, now chiefly in *Peru*.

Chryſolite, or *Beryl*, is of a light yellowiſh green; it melts *per ſe* into a ſlag; it is ſofter than cryſtal; it yields only to borax and microcoſmic ſalt, and is ſcarcely affected by alkalis: when ready to melt it becomes phoſphoreſcent.

Aqua Marine (augites) is of a bluiſh green; it melts *per ſe* by the blow-pipe.

IV. Variety.

Blue.

Sapphire.

Its colour is ſky blue; its texture foliaceous; its form hexangular or polyangular priſms or parallelipeds; its ſpecific gravity from 3,78 to 3,994; the oriental preſerves its colour in a porcelain heat, and will not melt *per ſe*, but that of *Brazil* loſes its colour; it is affected by fluxes as the other varieties.

Mr. *Bergman* found 100 parts of this ſtone to contain 58 of argill, 35 of ſilex, 5 of mild

mild calcareous Earth, and ,2 of iron; and Mr. *Achard* 58,33 of argill, 33,33 of ſilex, 6,66 of calcareous Earth, and 3,33 of iron.

Jewellers mention white, green, and yellow ſapphires, or pale red.

SPECIES VII.

Amethyſt.

Some of this ſpecies are as tranſparent as the former ſtones, others duller; its ſpecific gravity, which reaches only from 2,6 to 2,7, makes me judge it to be very different from them; its colour is pale bluiſh red; its texture nearly granular, and generally cryſtalized in hexangular priſms; it loſes its colour in a ſtrong heat, but does not melt *per ſe*, though with borax it gives a colourleſs glaſs; its compoſition has not yet been examined.

SPECIES VIII.

Siliceous Earth united to $\frac{1}{55}$ of its weight of Calcareous Earth, ſtill leſs of Magneſia, with an exceeding ſmall Proportion of Iron, Copper, and Sparry Acid.

Chryſopraſium.

It is of an apple green colour, and ſemitranſparent; it has never been found cryſtalized;

ſtalized ; it is much harder than green fluors or green quartz.

When diſtilled, a little of its Earth ſublimes ; it loſes its tranſparency and colour in fire, but does not melt *per ſe.*

Mr. *Achard* found 100 parts of it to contain 95 of ſiliceous Earth, 1,7 of calcareous Earth, 1,2 of magneſia, 0,4 of iron, and 0,6 of copper.

SPECIES IX.

Siliceous Earth intimately mixed with blue martial Fluor, and a ſmall Proportion of Gypſum.

Lapis Lazuli.

The colour of this ſtone is a beautiful opake blue, which varies a little in intenſity, and is generally ſprinkled over with yellow, bright, pyritaceous ſpecks or ſtreaks : it obſtinately retains its colour in a ſtrong heat, which diſtinguiſhes it from other blue ſtones : it is of an equable or very fine granular texture, and takes a beautiful poliſh : its ſpecific gravity is 3,054.

If powdered and not calcined, it effervesces very ſlightly with acids, but if calcined,

cined, it does not efferveſce, but becomes gelatinous.

In a ſtrong fire it melts *per ſe* into a *whitiſh* glaſs.

This ſtone has been examined by Mr. *Margraaf* only with a view of finding whether it contained copper. He found none, but only calcareous Earth, gypſum, iron, and ſilex. Mr. *Rinman* lately found it to contain the ſparry acid.

Species X.

Jade.

Jade is found in ſcattered maſſes like pebbles, ſemi-tranſparent, of a greaſy look, and exceeding hard: its colour is either white, grey, olive, green, or yellowiſh: its ſpecific gravity from 2,97 to 3,389. According to Mr. *Sauſſure*, it is ſcarcely ſoluble in acids, at leaſt without particular management, and alſo infuſible in fire. However, he ſeems to have extracted iron from it.

May it not be a compound of ſilex and magneſia?

SPECIES XI.

Siliceous Earth intimetely mixed and partly united with 0,209 of its weight of Argill, 0,164 of its weight of ponderous Earth, and 0,12 of its weight of Magnefia.

Felt-fpar, Spathum Pyromachum, Rhombic Quartz, Quartzum Spathofum, Spathum Durum, Petunfe.

This ftone, which is generally opake, is found of all colours, white, red, yellow, brown, green, violet, or iridefcent; fometimes cryftalized in rhombic, cubic, or parallelipedal forms, and often amorphous: its texture clofe but lamellar, and breaks like fpar: its fpecific gravity is from 2,4 to 2,6, and Mr. *Gerhard* fays he found it even 3,5; but it was then probably loaded with metallic particles: it is harder than fluors, but not fo hard as quartz.

It melts *per fe* more quickly and perfectly than fluors, into a whitifh glafs, and does not, like them, attack the crucibles. Borax and microcofmic falt entirely diffolve it without effervefcence, but it does not eafily enter into fixed alkalis. When cryftalized, it decrepitates in a moderate heat, otherwife not.

It

It never conſtitutes veins or ſtrata, but is either found in looſe maſſes at moſt 2 inches long, or mixed with ſand or clay, or imbodied in other ſtones, as granites, &c.

100 parts of the white contain about 67 of ſiliceous Earth, 14 of argillaceous, 11 of ponderous, and 8 of magniſia.

The ſpecific gravity of the ſpecimen I tried was 2,542.

Labrador ſtone is of this ſpecies; it reflects the colours of the rainbow, is ſomewhat ſofter than common felt-ſpar, and is found in pretty large pieces, generally of a dark grey colour: its ſpecific gravity is 2,755.

Felt-ſpar is undoubtedly the ſtone which the Saxons uſe as petunſe in their porcelain manufactories. 3 *Berlin Beſchaftig.* p. 471.

Species XII.

Siliceous Zeolyte.

This differs from that deſcribed under the argillaceous genus only in this, that it gives fire with ſteel. It is white, and found at *Mæſſiberg.* 3 *Bergm.* 224. It is very rare.

Species XIII.

Siliceous Earth imperfectly united to about 0,7 of its weight of Argill, and $\frac{1}{9}$ of its weight of Calcareous Earth, without Iron.

Vesuvian Garnet.

It is improperly called a garnet, as it contains no iron, and it differs from zeolyte in containing no water, and also in texture and hardness: its colour is white, sometimes opake and sometimes transparent, and very hard: it is difficultly acted on by any of the fluxes.

According to Mr. *Bergman*, it contains 55 per cent. of siliceous Earth, 39 of argill, and 6 of calcareous Earth.

Species XIV.

Siliceous Earth more or less perfectly united to 0,63 of its weight of Argill, about 0,4 of its weight of Calcareous Earth, and from 0,28 to about 0,41 of its weight of dephlogisticated Iron.

Garnet.

When not over-loaded with iron it is transparent, though, from the intensity of its colour,

lour, which is a bluifh or yellowifh red, its tranfparency is often obfcure, except it be held to a ftrong light: it is generally cryftalized in various polygon forms, but it is frequently amorphous: its texture is granular; its fpecific gravity from 3,6 to 4,188.

It melts *per fe*, though difficultly, into a black flag. Mineral alkali does not attack it fo powerfully as borax or microcofmic falt.

It retains its colour in a ftrong calcining heat.

It is often found in fmall grains, imbodied in ftones of the commoneft kind.

100 parts of it contain, according to Mr. *Achard*, 48,3 of filiceous Earth, 30 of argill, 11,6 of calcareous Earth, and 10 of iron.

Opake garnets, over-loaded with iron, fcarcely give fire with fteel, are fometimes cryftalized and fometimes amorphous, and either red, yellowifh, or blackifh. They afford about 20 per cent. of iron. Sometimes they contain tin and even lead, but very rarely. 2 *Bergm.* 106.

SPECIES XV.

Species XV.

Siliceous Earth more or leſs perfectly united to from 0,46 to 0,83 of its weight of Argill, from $\frac{1}{14}$ to $\frac{1}{9}$ of Calcareous Earth, and to $\frac{1}{5}$ or $\frac{1}{6}$ of ſemiphlogiſticated Calx of Iron, and from $\frac{1}{48}$ to $\frac{1}{58}$ of Magneſia.

Schoerl.

Its diſtinguiſhing properties are, 1ſt. either a ſparry or ſemi-vitrified appearance, like an enamel or a ſlag; 2d. a filamentous or ſcaly texture, which diſtinguiſhes it from garnets; the filaments either ſeparate from each other, or conjoined and plated; 3d. fuſibility *per ſe* in a moderate heat; 4th. a ſpecific gravity from 3, to 3,6, rarely 4,000, and only when loaded with iron; 5th its hardneſs nearly as that of cryſtal.

I. Variety.

Tranſparent.

This is always cryſtalized in ſome polygon form: its texture obſcurely ſparry: its colour brown, reddiſh brown, greeniſh or yellowiſh brown, or violet: its ſpecific gravity from 3, to 3,6.

A

A reddiſh brown, priſmatic ſhoerl of this ſort, from *Veſuvius*, contained, according to Mr. *Bergman*, 48 per cent. of ſiliceous Earth, 40 of argill, 5 of calcareous, 1 of magneſia, and 5 of iron. The uſual fluxes affect this ſpecies, as they do the foregoing.

The filamentous ſort reſembles aſbeſtos, and differs externally only in tranſparency and breaking with an even ſurface.

II. VARIETY.

Opake.

Theſe are of all colours, white, black, red, brown, greeniſh, and violet; the filaments are conjoined and parallel, or diverge, as from a common center. Thoſe of a ſcaly or ſparry appearance are generally greeniſh or black, and are called *Hornblende*. They are frequently cryſtalized in regular forms, and often ſo ſoft as to be ſcraped with a knife.

100 grains of the black cryſtalized ſort from *Albano*, afforded Mr. *Bergman* 58 of ſilex, 27 of argill, 5 of calcareous Earth, 1 of magneſia, and 5 of iron. 3 *Bergm.* 207. Other ſorts have afforded 50 per cent. of ſili-

ceous Earth, 30 of argill, 1 or 2 of magnesia, and 18 or 20 of iron.

The white ſort probably contains leſs iron.

All theſe ſorts become reddiſh by calcination.

Species XVI.

Siliceous Earth imperfectly united with 0,34 *of its weight of Calcareous Earth*, 0,107 *of its weight of Argill*, 0,08 *of Magneſia*, 0,026 *of Iron*, *and about* 0,048 *of Water.*

Bar Shoerl, Stangen Shoerl of the Germans.

This was lately found in the Carpathian Mountains by Mr. *Fichtel*, imbodied in limeſtone, and cryſtalized in priſms: it ſlightly efferveſces with acids.

According to Mr. *Bindheim*, 100 parts of it contain 61,6 of ſiliceous Earth, 21,6 of calcareous Earth, 6,6 of argill, 5 of magneſia, 1,6 of iron, and 3 of water. 3 *Schrift. Naturforſch. Freunde*, p. 452.

Species XVII.

SPECIES XVII.

Siliceous Earth imperfectly united with from 1,05 to 1,47 of its weight of Argill, from 0,3 to 0,4 of its weight of mild Calcareous Earth, and from 0,15 to 0,243 of its weight of Iron.

Tourmaline.

Tourmaline has hitherto been found only in *Ceylon*, *Brazil*, and the *Tyrol*. A ſpecimen of each has had the advantage of having been particularly examined by Mr. *Bergman*. That of *Ceylon* is of a dark brown, or yellowiſh colour, its ſpecific gravity 3,065, or, 3,295; that of *Brazil* is green, blue, red, or yellow, and its ſpecific gravity 3,075 or 3,180; that of *Tyrol*, by reflected light, is of a blackiſh brown, but by refracted light, yellowiſh, or in thin pieces, green; its ſpecific gravity 3,050; moſtly cryſtalized in polygon priſms, but ſometimes amorphous. The thickeſt parts are opake: the thin more or leſs tranſparent.

All are electric when heated to about 200 of *Fahrenheit*. Their texture is lamellar, and their ſurface has a glaſſy appearance.

In fire none of them decrepitate; but thoſe of *Ceylon* and *Tyrol* melt *per ſe* into a black

black frothy ſlag. That of *Brazil* forms only a brittle ſcoria. Of the uſual fluxes, borax diſſolves them beſt, microcoſmic ſalt and mineral alkali partially.

The proportion of their conſtituent principles is thus exhibited by Mr *Bergman*:

Tourmaline of Tyrol.

Argill, - - -	42
Silex, - - -	40
Calcareous Earth, - -	12
Iron, - - -	6
	100

Tourmaline of Ceylon.

Argill, - - -	39
Silex, - - -	37
Calcareous Earth, - -	15
Iron, - - -	9
	100

Tourmaline of Brazil.

Argill, - - -	50
Silex, - - -	34
Calcareous Earth, - -	11
Iron, - - -	5
	100

SPECIES XVIII.

SPECIES XVIII.

Siliceous Earth mixed with 0,3 of its weight of Argill, 0,17 of mild Calcareous Earth, 0,04 of Magnesia, and 0,5 of Iron.

Basaltes, Trapp of the Swedes, Saxum Danemorense.

A dark grey or black stone, generally invested with a ferruginous crust and crystalized in opake triangular or polyangular columns, is called basaltes; that which is amorphous, or breaks in large, thick, square pieces, is called *trapp*. Their constituent principles, and relation to acids and fluxes, are exactly the same. The texture of this stone is either coarse, rough, and distinct, or fine and indiscernable. This latter sort is often reddish; it is always opake, and moulders by exposure to the air; some specimens give fire with steel very difficultly, though it is always very compact; sometimes it is sprinkled over with a few minute shining particles: its specific gravity is 3,000.

When heated red hot, and quenched in water, it becomes by degrees of a reddish brown colour: it melts *per se* in a strong heat into a compact slag. Borax also dissolves it in fusion, but mineral alkali not intirely.

According to Mr. *Bergman*, 100 parts of the basaltes contain 52 of siliceous Earth, 15 of argill, 8 of calcareous, 2 of magnesia, and 25 of iron. 3 *Bergm.* 213. And with this Mr. *Meyer* very nearly agrees. 14 *Naturforsh.* 5.

Species XIX.

Siliceous Earth mixed with 0,69 of its weight of Argill, and 0,41 of its weight of Iron in a semiphlogisticated state.

Rowly Ragg.

This stone is also of a dusky or dark grey colour, with numerous minute shining crystals; its texture granular; by exposure to the air it acquires an ochry crust; its specific gravity 2,748.

Heated in an open fire it becomes magnetic. In a strong heat it melts *per se*, but more difficultly than basaltes.

According to Dr. *Withering's* analysis, 100 parts of it contain 47,5 of siliceous Earth, 32,5 of argill, and 20 of iron.

SPECIES XX.

Siliceous Earth more or less perfectly united to from $\frac{1}{3}$ to $\frac{9}{10}$ of its weight of Argill, 0,3 or 0,4 of its weight of Iron, and a small proportion of pure Calcareous Earth, but this is sometimes wanting.

Lava.

By *Lava* I underſtand the immediate product of liquefaction or vitrification by volcanic fire, which ſhould carefully be diſtinguiſhed from the ſubſequent productions affected by the water either in a liquid or fluid ſtate, which generally is ejected at the ſame time.

All lavas are more or leſs magnetic, give fire with ſteel, are of a granular texture, and fuſible *per ſe.* Moſt are decompoſable by long expoſure to the air, ſooner or later, according to the proportion of iron and calcareous Earth, and according as they were more or leſs perfectly melted or vitrified.

Mr. *Bergman*, in his elaborate treatiſe on volcanic products, diſtinguiſhes three varieties of lava; the cellular or frothy, the compact, and the vitreous.

 I. VARIETY.

I. Variety.

Cellular Lavas.

Theſe underwent only the firſt and loweſt degree of fuſion, being juſt mollified and heated ſufficiently to expell the fixed air contained in the argillaceous particles; hence they abound in ſmall cavities ariſing from the expanſion of that air after it had recovered its elaſtic ſtate. Their ſpecific gravity is various: ſome are ſo light, by reaſon of their internal cavities, as to float for ſome time on water, and hence, have been miſtaken for pumice ſtones, but they differ from theſe in this, that their texture is never filamentous.

Their colour is black, grey, brown, or reddiſh brown, and their cavities are often filled with cryſtalizations.

Of this ſort is the black cellular mill-ſtone of the *Rhine*.

Theſe ſtones contain from 45 to 50 per cent. of ſilex, and from 15 to 20 per cent. of iron, 4 or 5 per cent. of pure calcareous Earth, and the remainder argill.

II. Variety.

II. Variety.

Compact Lavas.

Theſe have undergone the 2d or more perfect degree of fuſion, yet they are not entirely deſtitute of cavities which contain finer cryſtals, or pieces more perfectly vitrified; their colour is black or brown; their fracture is ſtill obſcure, and not glaſſy, as the ſtones themſelves are opake: if not cracked, they give a clear ſound when ſtruck.

The proportion and quality of their conſtituent parts are the ſame as in the foregoing variety. The uſual fluxes attack them with difficulty, and microcoſmic ſalt has ſcarce any power over them.

III. Variety.

Vitreous Lavas.

Theſe have been more completely melted, and form vitrifactions of different colours, generally black or aſh-coloured, rarely blue or greeniſh.

A ſpecimen of this glaſs, examined by Mr. *Bergman*, afforded 49 per cent. of ſilex,

35 of argill, 4 of pure calcareous Earth, and 12 of iron. Another ſpecimen from the *Lipari Iſlands* afforded 69 of ſilex, 22 of argill, and 9 of iron. This muſt have been expoſed to a very ſtrong heat, for they melt very difficultly *per ſe*.

The *black Agate of Iceland*, (*Lapis obſidianus*, *Piedra de Galinaço*) is of this ſort, and its principles and their proportions nearly the ſame.

The harder ſort of pitch ſtones, already deſcribed, which give fire with ſteel, belong to this ſpecies.

Mr. *Sauſſure* has ingeniouſly imitated all theſe ſpecies of lava, by melting more or leſs perfectly the compound argillaceous ſpecies into which hornſtone enters as the moſt copious ingredient, and which he therefore calls *Hornrock*, *Roche de corne*, and which are already deſcribed. *Voyage dans les Alpes*, p. 127. And hence he juſtly conjectures that this ſtone, marl, and the ſchiſti (Species 6, 7, and 8 of the Argillaceous Genus) are the principal materials of lava. *Ibid*, 131, 132.

SPECIES XXI.

SPECIES XXI.

Siliceous Earth mixed with 0,11 *or* 0,17 *of its weight of Magnesia, and a little of Calcareous Earth.*

Pumice-stone, Pierre Ponce, Bimstein.

This seems rather a volcanic ejection than a volcanic product; its colour is grey, white, reddish brown, or black: it is hard, rough, and porous, and consists of slender fibres parallel to each other; very light, for it swims on water, and difficultly gives fire with steel. It seems to have originally been an asbestos decomposed by the action of fire.

100 parts of it contain, according to Mr. *Bergman*, from 6 to 15 of magnesia, with a very small proportion of calcareous Earth, the remainder silex.

SPECIES XXII.

Siliceous Earth mixed with less than its own weight of Magnesia and Iron.

Martial Muriatic Spar.

Mr. *Monnet*, a Mineralogist of considerable note, lately discovered this stone at *St. Marie aux Mines*, and called it *pisolites*; but as a very

very different compound is generally denoted by this name, I have called it martial muriatic ſpar, a name which agrees better with its properties.

It is of a hard, ſolid, and ſparry texture; of a grey, ochry, dull colour, but internally bright: it gives fire with ſteel, yet effervesces with acids.

In a ſtrong heat it grows brown, but at laſt melts *per ſe.*

100 parts of it contain 50 of ſilex, the remainder mild magneſia and iron, but in what proportion is not mentioned. 13 *Roz. Suppl.* 416.

SPECIES XXIII.

Siliceous Earth intimately mixed with $\frac{1}{3}$ *of its weight of mild Calcareous Earth.*

Turky Stone, Cos Turcica.

This is of a dull white colour, and uneven texture; ſome parts appearing more compact than others, ſo that it is in ſome meaſure ſhattery: it hardens with oil; its ſpecific gravity is 2,598; it gives fire with ſteel, yet effervesces with acids.

I

I found 100 parts of it to contain 25 of mild calcareous Earth, and no iron. There probably are two ſorts of ſtone known by this name, as Mr. *Walerius* affirms that which he deſcribes, neither to give fire with ſteel, nor efferveſce with acids.

Species XXIV.

Siliceous Earth mixed with mild Calcareous Earth and Iron.

Ragg-ſtone.

Its colour is grey; its texture obſcurely laminar, but the laminæ conſiſt of a congeries of grains of a quartzy appearance, coarſe and rough; its ſpecific gravity is 2,729; it efferveſces with acids, and gives fire with ſteel. I found it to contain a portion of calcareous Earth, and a ſmall proportion of iron. It is uſed as a whetſtone.

Species XXV.

Arenaceous Quartz conſolidated by a ſmaller proportion of Calcareous Earth, or Argill, and ſtill a ſmaller of Iron.

Siliceous Grit, Sandſtone, Freeſtone, Cos Arenarius, Grais.

Under this ſpecies I comprehend only ſuch as ſtrike fire with ſteel, and when pounded,

pounded, form a ſand rather than a powder.

I. Variety.

Grit with a Calcareous Cement, Quadrum.

A ſtone of this ſort hath been already deſcribed under the calcareous genus. When it contains about 50 per cent. or more of ſilex it belongs to this ſpecies; it commonly contains alſo a ſmall proportion of argill and iron; it hardens by expoſure to the air, and then ſtrikes fire with ſteel, and effervesces ſlightly with acids: it is ſometimes cryſtalized in rhomboids, as at *Fontainbleau*. 100 parts of this contain, by the experiments of Mr. *Laſſone*, 62,5 of ſilex and 37,5 of mild calcareous Earth. *Mem. Par.* 1777, p. 43.

The *Saxum margariticum* of *Linneus* belongs alſo to this ſpecies: it conſiſts of quartz in a calcareous cement.

II. Variety.

With an Argillaceous Cement.

Theſe do not effervesce with acids, but they ſtrike fire with ſteel, though ſome ſorts are too ſoft to do ſo until expoſed for ſome time to the air. The free-ſtone from *Keredge*, near *Macclesfield*, which is of a cloſe grain, is of this ſpecies. Its ſpecific gravity is 2,544.

So

So alſo that of *Brownedge*, in *Staffordſhire*, which is ſo perfect a ſand-ſtone that its ſpecific gravity is only 2,397; and the whitiſh grey freeſtone from *Uttoxeter*. All theſe contain a little of iron.

Stones of this ſpecies are uſed for whetting tools, and for filtring water, and in ſome countries as ſlates. The principal diſtinction among them ariſes from the fineneſs or coarſeneſs of their grain and texture. Their colours are various, receiving different tinges from iron.

Species XXVI.

Siliceous Sand conſolidated by ſemiphlogiſticated Calx of Iron.

This ſtone does not fall into ſand when powdered, and in this reſpect differs from the foregoing. It is generally of a brown or black colour, but grows reddiſh or yellowiſh, and moulders by expoſure to the air ; its ſpecific gravity is from 2,8 to 3,6 ; it gives fire with ſteel, and does not efferveſce with acids, unleſs it contains teſtaceous particles, as it frequently does : it is even often covered with ſhells.

The agglutinating power of ſolutions of iron has been ſhewn in an ingenious paper in the

the Philoſophical Tranſactions for 1779, p. 35, by Mr. *Edward King*, who found a ſtony concretion of this ſort round iron, which had been long buried in the ſea.

Mr. *Gadd*, in the Swediſh Memoirs for 1770, relates, that Mr. *Rinman* had found a ſimilar concretion round an old anchor that had long been depoſited in the ſea. He alſo adds, from his own experiments, that dephlogiſticated calces of iron, and particularly ſolutions made by the mineral acids, have not the ſame binding power, but, on the contrary, make looſe concretions, as Dr. *Higgins* has alſo ſhewn in a late very uſeful treatiſe on cements.

To this ſpecies may be added the *black, heavy, gloſſy Quartz* of *Cronſted*, § 53, which he ſays is found in the mine of *Staf*, in *Sudermanland*, and contains a large proportion of iron.

Compound Species in which the Siliceous Genus predominates.

Species I.

Compounds of the different Species of the Siliceous Genus with each other.

I Variety.

I. Variety.

Quartz and Shoerl.

This ſtone conſiſts of diſtinct grains of each compacted together in various proportions. The quartz is generally white, or reddiſh; the ſhoerl, black, brown, white, or green: by ſome it is called a *granite*. Some of the paving-ſtones of *London* are of this ſort.

II. Variety.

Quartz and Felt-ſpar.

The quartz is generally white; the felt-ſpar red, yellow, or brown: found in the *Alps* by Mr. *Sauſſure*, from whoſe excellent work many of the following deſcriptions are taken. Mill-ſtones and whet-ſtones are often of this ſort.

III. Variety.

Jade and Shoerl.

The ſhoerl is interſperſed through the jade; in a ſtrong fire it melts, but the jade only whitens. *Sauſſure Voyage dans les Alpes*, p. 84. Its ſpecific gravity is from 3,318 to 3,389. The jade is yellowiſh, the ſhoerl green or black.

IV. VARIETY.

Jade, Shoerl, and Garnet.

Of confiderable hardnefs and weight, with large fpots of red, green, and yellow; the garnet red, the fhoerl green, and the jade yellow. *Sauffure*, p. 107.

V. VARIETY.

Quartz, Felt-fpar, and Shoerl,

Granite.

Thefe are fo well adapted to each other, that, as Mr. *Sauffure* well remarks, they could not have been fo compacted by an accidental mixture of maffes previoufly formed, but muft have cryftalized together. It may be feen among the paving ftones of *London.* The quartz is white, the fhoerl black or violet, and the felt-fpar reddifh.

VI. VARIETY.

Puddingftone, Breccias.

Stones which confift of a filiceous ground or cement, (commonly petro-filex, jafper, or filiceous grit) in which pebbles of filex or agate are interfperfed; if thefe be round or oval, are called *puddingftones*; if angular, *breccias.* Of the coarfer forts mill-ftones are often made. *Mem. Par.* 1758.

VII. Variety.

Coral Stone.

This is an aggregate of onyx, ſardonyx, rnelian amethyſt, and quartz.

Species II.

Compounds of the Siliceous with the Calcareous Species.

I. Variety.

Quartz and Spar.

Diſtinct grains of each compacted together; the quartz generally white and ſemi-tranſparent; the ſpar of a browniſh yellow. *Sauſſure*, 104.

Species III.

Compounds of the Siliceous and Barytic Species.

Species IV.

Compound of the Siliceous and Muriatic Species.

I. Variety.

Quartz, Felt-ſpar, and Serpentine.

II. Variety.

Shoerl and Soap-rock.

Compacted of diſtinct maſſes of each, *Sauſſure* 104. The ſoap-rock is green, and

 the

the ſhoerl black. It gives fire with ſteel, when the ſhoerl is ſtruck.

III. Variety.

Quartz and Steatites.

Obſerved alſo by Mr. *Sauſſure*, the quartz white, and the ſteatites green.

IV. Variety.

Qtartz, Shoerl, and Steatites.

The ſteatites incloſed in the quartz in the form of black kernels.

Species V.

Compounds of the Siliceous, and Argillaceous Species.

I. Variety.

Quartz and Mica. Stellſten of the Swedes. Granitello.

It ſtrikes fire with ſteel, and does not eaſily melt; and hence uſed for furnaces, &c. When the mica abounds it is of a lamellar texture, its colour is generally grey, or green; the mixture of mica prevents the ſilex or quartz

quartz from cracking or ſpliting; and hence its infuſibility and uſe in furnaces.

II. Variety.

Feltſpar and Mica,

Granitone.

This ſtone is mentioned by *Ferber*, in his letters from *Italy*, p, 118. A ſtone of this ſort which moulders by expoſures to the air, is found in *Finland*, and is ſaid to contain ſometimes ſaltpetre, and ſometimes common ſalt, it is there called *Rapakivi*, 1 Linné von Gmelin, 621.

III. Variety.

Quartz and Horn-ſtone.

In ſmall diſtinct grains compacted together, this is found plentifully in the mountain of *Penmaumaure* in *Wales*. It exhales an earthy ſmell, gives fire with ſteel, and is of a thick lamellar texture: its ſpecific gravity is 2,811. the quartz is white, and the horn-ſtone black, which gives the ſtone a bluiſh appearance.

IV. Variety.

Quartz, Feltſpar, and Mica, or Quartz, Shoerl and Mica.

Granite, Moor-ſtone.

This ſtone conſiſts of diſtinct maſſes of each, firmly compacted together, their pro-

 portion

portion and ſize are extremely variable, as well as their colour. The three firſt conſtitute the hardeſt ſort of the granite, and moſt anciently known; that into which the ſhoerl enters, is more ſubject to decompoſition; it never has any particular texture, but conſiſts of enormous ſhapeleſs maſſes, of great hardneſs.

In the finer granites, the quartz is tranſparent, in others generally white or grey, violet or brown; the feltſpar, white, yellow, red, green or black, it is generally the moſt copious ingredient. The mica is alſo grey, brown, yellow, green, red, violet or black, and is commonly leaſt copious. The ſhoerl is generally black, and abounds in the granites that contain it. Hence the colour of granites chiefly depends of the feltſpar or ſhoerl. The *red* granites conſiſt commonly of white quartz, red feltſpar, and grey mica. The *grey* of white quartz, grey or violet feltſpar, and black mica. The *black* commonly contain ſhoerl, inſtead of feltſpar. The *green* commonly contain greeniſh quartz.

If granite be expoſed to a blow-pipe, its different concretions ſeparate from each other. In a crucible, Mr. *Gerhard* found the feltſpar melted into a tranſparent glaſs; under it the mica lay in the form of a black ſlagg, and the

the quartz remained unaltered; but when all three are powdered and mixed, it melts ſomewhat better, yet ſtill the quartz may be diſtinguiſhed by the help of a lens. *Gerb. Geſch.* § 51. This well explains why ſmall white grains are frequently found in lavas. ~~Mr.~~ *D'Arcet's* experiments coincide with this, and also thoſe of Mr. *Sauſſure*, p. 124.

V. VARIETY.

Quartz, Feltſpar, Shoerl and Mica.

This is alſo a ſort of granite obſerved by Mr. *Sauſſure* in the Alps.

VI. VARIETY.

Jade, Shoerl, and Mica.

A ſort of granite obſerved by Mr. *Sauſſure.*

VII. VARIETY.

Quartz, Garnet, and Mica, Norka, Murkſtein.

This is either grey or reddiſh, and uſed for mill-ſtones, the mica is ſoon wore off.

VIII. VARIETY.

Porphyry.

Under this name I comprehend with Mr. *Sauſſure*, all thoſe ſtones which in a compact

ſiliceous ground (generally jaſper, chert, ſhoerl, or lava) contain either feltſpar, quartz, ſhoerl, mica, ſerpentine, or other ſpecies of ſtone in a *cryſtaline* form. When its ground is jaſper it is hard. It is commonly either red, purple, grey, green, or black, according to the ground. The *red* commonly contains feltſpar in ſmall white dots or ſpecks, and often together with theſe black ſpots of ſhoerl. The *green* is either a jaſper or ſhoerl, with ſpots of quartz or ſhoerl. Sometimes a porphyry of one colour contains a fragment of a porphyry of another colour; the green are often magnetic. Thoſe that have chert for their ground, are fuſible *per ſe*.

Species VI.

Compounds of the Siliceous, and various Genera.

I. Variety.

1. *Quartz, Mica, and Serpentine.*

2. *Quartz, Mica, and Steatites.*

3. *Quartz, Mica, and Shoerl, together with Serpentine or Steatites, or Soap-rock.*

4. *Quartz, Felt-ſpar, Mica, and Serpentine.*

All

All theſe ſtones are called *Gneiſs*, and are generally of a lamellar texture.

II. Variety.

Amygdaloides, Mandelſtein of ſome.

This conſiſts of a chert or jaſper ground, in which fragments of calcareous ſpar, and ſerpentine, of an oval form, are contained.

III. Variety.

Variolite.

This is ſaid to be a compound of all ſorts of ſtones, included in a ground of ſerpentine. *Ferber. Italy*, p. 120.

IV. Variety.

Metallic Stone of Linnæus and Born.

It conſiſts of Quartz, clay, and ſteatites, and is of different degrees of hardneſs, ſometimes the ſteatites is wanting, ſometimes feltſpar is found in it.

V. Variety.

Quartz, Spar, and Mica. Saxum Angermannicum of Linnæus.

CHAP.

CHAP. IX.

Of Vegetable and Animal Earths.

Vegetable Earth has been thought by many to be of a peculiar nature, ſpecifically different from every other; but late experiments have fully ſhewn.

1$^{st.}$ That vegetables contain but a very ſmall proportion of Earth of any ſort, and that far the greater part of their ſubſtance conſiſts of water, fixed air, and inflammable air in a concrete ſtate, as remote principles, a ſmall proportion of fixed alkali which probably is neutralized by vegetable acids, and a few other neutral ſalts. Thus according to the lateſt experiments, 33 pound of oak afford only 3 drachms of aſhes. *Memoirs of Stockholm*, 1781.

2$^{dly.}$ That the Earth of vegetables is for the greater part, either calcareous, or a mixture of all ſorts of Earths, and ſometimes of the calces of iron and manganeſe, in various proportions, according to the ſpecies of the vegetable. Thus Mr. *Bergman* found the aſhes of ſome vegetables to contain calcareous, ponderous, muriatic, argillaceous, and even ſiliceous Earth; and hence aſhes effervesce with acids, and are fuſible *per ſe*, even after perfect

perfect lixiviation. He also found sometimes animal Earth, (that is phosphoric selenite,) in ashes. The Earth remaining after the putrefaction of vegetables, is exactly of the same nature. *Schæffer*, § 172. Mr. *Morveau* found the ashes of some vegetables to contain 97,5 per cent. of calcareous Earth, the remainder magnesia. Mr. *Berniard*, Mr. *D'Arcet*, and Mr. *Achard*, have had nearly the same results. 19 *Roz.* 52.

The neutral salts most usually found in ashes, are tartar vitriolate, glauber's salt, common salt, digestive salt, and selenite, also hepar sulphuris; according to *Model* a pound of rhubarb contains an ounce and a half of selenite.

Hence we see why clay is so unfavourable to vegetation, and how calcareous Earth is introduced into the bodies of animals.

Animal Earth, is obtained either from the shells of fish, or from those of eggs, or from pearls, or from the bones, horns, claws of land animals, or from the skins of insects.

That obtained from the shells of fish and from those of eggs, is found by repeated experiments to be purely calcareous; only oyster shells discover some feeble vestiges of selenite. *Bergm.* on *Scheffer*, § 173, that obtained from

from bones, horns, claws, teeth, &c. was found by Mr. *Gahn*, to be a calcareous Earth united to the phoſphoric acid; hence the ſolution of bones in the mineral acids can never be neutralized, a circumſtance which puzzled all preceeding chymiſts, but which is now perfectly underſtood, as ſuch ſolution is in fact only the ſolution of a neutral ſalt if the bones be diſſolved in the nitrous or marine acids, or a decompoſition of a neutral ſalt, if the vitriolic acid be uſed as a ſolvent; in either caſe a free unſaturated acid muſt be found. However ſome bones contain an exceſs of phoſphoric acid, and ſome an exceſs of Earth, as ivory, whence ſome have imagined this latter to contain a peculiar Earth. Some late and accurate experiments relating to the proportion of phoſphoric acid in bones by Mr. *Berniard*, may be ſeen in *Rozier's* journal, for 1781, p. 280, 1782, p. 43.

The phoſphoric acid is ſeparated from this Earth by calcining the bones to whiteneſs then diſſolving them in nitrous acid, and precipitating the calcareous Earth by the concentrated acid of vitriol. A ſelenite is thus obtained (decompoſable either by calcination with charcoal, or by boiling in a ſolution of mild fixed alkali, and the phoſphoric acid remains in the liquor.

APPENDIX

APPENDIX I.

Of Diamond and Plumbago.

Theſe ſubſtances cannot well be arranged under any of the claſſes of minerals; not under that of Earths as they contain no Earth, nor under that of inflammables, as their inflammability commences in ſuch high degrees of heat, and is ſo gradual that it can ſcarcely be remarked but by its effect in diminiſhing the weight of theſe ſubſtances after a long expoſure to fire; ſo that they differ intirely from all other inflammables, whence I think it convenient to treat of them a part.

Diamond.

Diamond is always tranſparent, and moſtly colourleſs, but ſometimes tinged, yellow, reddiſh, green, blue, or brown; it is ſometimes externally, but always internally bright; it is generally cryſtalized in octohedral cryſtals, but ſometimes found in round maſſes: its texture is lamellar.

It ſtrikes fire with ſteel, cuts the hardeſt cryſtals, and even rubies, being the hardeſt of all bodies: its ſpecific gravity is from 3,5 to 3,66.

No

No acid has any effect on it, except the vitriolic; if diamond powder be triturated with this acid, and evaporated nearly to dryneſs, the acid grows black and depoſits pellicles, which burn and are almoſt entirely conſumed.

In a heat ſomewhat greater than that in which ſilver melts, diamond is intirely volatilized and conſumed; it even produces a ſlight flame and diminiſhes common air, juſt as phlogiſtic ſubſtances do, and leaves a ſoot, ſo that the extraordinary conjecture of Sir *Iſaac Newton*, of its being an inflammable ſubſtance coagulated is fully confirmed. Of the uſual fluxes, only borax and microcoſmic ſalt have any effect on it.

It is found in *Golconda*, *Viſapour*, *Bengal*, the iſland of *Borneo*, *and Brazil.*

The nature of cubic diamonds has notyet been examined.

Plumbago, *Reiſsbley*, *of the German's*, *Blyertz*, *of the Swedes.*

This ſubſtance is externally black, but bluiſh white and ſhining like a metal when freſh cut: its texture is micaceous and ſcaly, yet granular. It is uſed for pencils.

It is too ſoft to ſtrike fire with ſteel: its ſpecific gravity is from 1,987, to 2,267.

It is inſoluble in the mineral acids.

In a ſtrong heat and open fire it is wholly volatile, leaving only a little iron, which ſeems to be only accidentally found in it, and a few grains of ſilex.

The uſual fluxes do not effect its fuſion.

It is decompoſed by detonnation with nitre, in a red hot crucible.

According to Mr. *Scheele*, who firſt diſcovered the nature of this mineral, 1 part plumbago requires 10 of nitre to decompoſe it, whereas 1 part charcoal requires but 5 of nitre: hence it contains twice as much phlogiſton as charcoal does. By receiving the air ariſing from its decompoſition in a bladder, he found $\frac{1}{3}$ of that air to be abſorbable by lime water, and conſequently to be fixed air, and in the remainder a candle would burn: but as nitre itſelf might afford fixed air by combuſtion, to get rid of all objections, he decompoſed plumbago by ſubliming and reducing the arſenical acid, after mixing it with plumbago; and thus alſo he obtained fixed air. It is probable that 100 grains of it contain

tain 33 of aerial acid, and 67 of phlogiston; for 100 grains of nitre contain about 33 of real nitrous acid. This is decomposed when it receives as much acid as is necessary to convert it into nitrous air, or a little more. Now 33 grains of nitrous acid are converted into nitrous air by about 6,7 grains of phlogiston: then 1000 grains of nitre require for their decomposition 67 of phlogiston: and since 100 grains of plumbago decompose 1000 of nitre, they must contain 67 of phlogiston.

APPENDIX II.

Of the general Examination and Analysis of Earths and Stones.

SECTION I.

Of the Examination of Earths.

When Earths are well dried and separated from every visible heterogeneity, a portion of them should be weighed and distilled in a glass retort, until the bottom begins to grow red hot. In some cases it may be proper to receive the air that arises, in a pneumatic apparatus; in all it will be proper to examine what distills over, or sublimes, whether it be acid or alkaline, with paper tinged blue by litmus, and partly reddened by distilled vinegar: if the blue

blue be reddened, an acid exists in the distilled liquid; if the red be effaced, and the blue restored, a volatile alkali is the cause of it: if the liquor precipitates lime water, but does not precipitate nitrous selenite, then it contains fixed air: if it precipitates also nitrous selenite, it contains the vitriolic acid: if it contains the marine acid, it will not precipitate nitrous selenite, but it will the nitrous solution of silver. The loss of weight of the residuum in the retort, and the weight of the water in the receiver, will shew the proportion of the volatile ingredients.

Another portion should be digested in about 6 or 8 times its weight of pure water, and the properties of that water examined, to find whether the Earth contains neutral salts. Here the method given by Mr. *Bergman* in his analysis of mineral waters, should be followed.

SECTION II.

Of the general Examination of Stones.

Their specific gravity should first be examined; also their hardness; whether they will strike fire with steel, or can be scratched by the nail, or only by crystal or stones of still greater hardness; also their texture, perviousness

neſs to light, and whether they be manifeſtly homogenous or compound ſpecies, &c.

2d. In ſome caſes one ſhould try whether they imbibe water, or whether water can extract any thing from them by ebullition or digeſtion.

3d. Whether they are ſoluble in, or effervefce with acids, before or after pulverization; or whether decompoſable by boiling in oil of tartar, &c. as gypſums and ponderous ſpars are.

4th. Whether they detonnate with nitre.

5th. Whether they yield the ſparry acid by diſtillation with oil of vitriol, or a volatile alkali, by diſtilling them with ſalt of tartar.

6th. Whether they are fuſible *per ſe* with a blow-pipe, and how they are affected by mineral alkali, borax, and microcoſmic ſalt; and whether they decrepitate, when gradually heated.

7th. Stones that melt *per ſe* with the blow-pipe are certainly compound, and contain at leaſt 3 ſpecies of Earth, of which the calcareous is probably one; and if they give fire with ſteel, the ſiliceous is probably another.

SECTION III.

SECTION III.

Of the Analyſis of Earths and Stones.

The beſt general ſolvent for Stones or Earths ſeems to me to be *Aqua Regia*, compoſed of two parts nitrous, and one of marine acid: if the ſtone or Earth effervеſces ſtrongly with acids, no other preparation is requiſite than a ſeparation of ſuch parts as are viſibly heterogenous, and pulverization; the ſolution is then eaſily performed in a digeſting heat, if requiſite. The undiſſolved reſiduum, if purely ſiliceous, will melt into a tranſparent glaſs with about ½ its weight of mineral alkali; if not, it is ſtill compounded, and its ſoluble parts will yield to a reiterated digeſtion.

If the ſtone does not effervеſce, or eaſily diſſolve in acids, after pulverization and digeſtion, but leaves an inſoluble reſiduum evidently compound, or but ſlightly altered, it will require to be pulverized and mixed with twice or thrice its weight of mineral alkali, and to be expoſed to a low red heat for one or two hours. I found mica to require a mixture of 4 times its weight of mineral alkali; after which it is to be ſeparated from the alkali by lixiviation and filtration, waſhing it with diſtilled water until the

water is abſolutely taſteleſs and precipitates no metallic ſolution.

The powdered ſtone, thus edulcorated, is to be dried by heating it to redneſs, and then weighed, and 100 grains taken for ſubſequent experiments: it were better if ſtill more were uſed, but the analyſis would be more expenſive.

The powder is next to be digeſted in 8 or 10 times its weight of *aqua regia*, in a boiling heat in a retort to which a receiver is luted, and the digeſtion reiterated as long as any thing appears to be diſſolved by freſh portions of the acid. I found mica to require 50 times its weight of *aqua regia* before it was entirely decompoſed, as the acid is ſo volatile as very ſoon to diſtill over. Oil of vitriol has the advantage of bearing a greater heat, diſſolving baroſelenite, and of acting more powerfully on argill than *aqua regia*; but a large retort muſt be uſed, for, often towards the end it puffs and throws up the Earth or ſtone, and carries it into the receiver; and it does not ſufficiently act on calces of iron, if theſe be much dephlogiſticated. Spirit of nitre affects them ſtill leſs: hence I often uſe oil of vitriol firſt, then precipitate by a mild alkali what it has diſſolved, and rediſſolve the precipitate in *aqua regia*. A perfect ſolution

tion being thus effected, the residuum is to be well washed, and the washings added to the solution: the residuum, well dried and weighed, gives the weight of siliceous Earth in the compound.

The solution is next to be examined; which I will suppose to contain the 4 soluble Earths, calcareous, ponderous, magnesia, and argill, and also a calx of iron: it always contains an excess of acid, of which it is in great measure deprived by boiling for a considerable time, as both acids are very volatile, and indeed, of the marine none remains but what is combined with the calx of iron, as the nitrous chases it from the Earths. By getting rid of this excess of acid, less alkali will be required for the succeding precipitation, and less aerial acid set loose which would retain much of the precipitate by re-dissolving it: the solution should then be evaporated to about ½ a pint.

The solution being thus prepared, it is usual to precipitate the calx of iron from it by the Prussian alkali; but to this method I have two objections; 1st. that the ponderous Earth, if any, would also be precipitated and confounded in the Prussian blue; and 2d. that this precipitation, besides being exceeding slow, seldom fails of leaving some iron still

in the ſolution, as the exceſs of the Pruſſian alkali, which muſt neceſſarily be added, to be certain that all the iron is precipitated, never fails to re-diſſolve a portion of the Pruſſian blue which thus remains in the liquor, and cannot be got rid off. Hence the method I uſe is as follows: firſt, I prepare the Pruſſian alkali after the manner of Mr. *Bergman*, by digeſting and boiling a pure alkaline ſolution over Pruſſian blue, until the alkali no longer efferveſces with acids, nor precipitates a ſolution of nitrous ſelenite, or any other Earth, except the barytes: I even make it a little ſtronger; for if it be barely ſaturated with the tinging matter, it ſoon ſpoils and precipitates other Earths, the tinging matter evaporating. I next examine how much of this alkali is neceſſary to precipitate 1 gr. of iron from its ſolution in dilute vitriolic or marine acid, and I mark this on the label of the bottle that contains the alkali. I now come to the application.

The ſolution of the earths being weighed I take 100 grains of it, and on theſe I gradually pour the Pruſſian alkali (a portion of which is alſo previouſly weighed) until all the iron, or ponderous Earth and iron, is precipitated; the weight of the alkali uſed, gives that of the iron contained in 100 grains of the ſolution, and the quantity contained in

100 gr. of the solution, gives that contained in the whole solution, by the rule of proportion, from which the ponderous Earth, if any be found in subsequent experiments, is to be deducted.

The quantity of iron being thus found, the remainder of the solution is to be precipitated by aerated mineral alkali, and then boiled for half an hour to expel as much as possible of the fixed air; by this means the whole of its contents are precipitated, and nothing remains in solution, but cubic nitre and a little common salt; when the precipitate has settled after one or two days rest, the liquor is to be poured off, and the last portions taken up with a glass syringe. Distilled water is then to be added to the precipitate and boiled over it, and afterwards poured off and taken up until it comes of tastless.

The precipitate being sufficiently dried, is to be re-dissolved in nitrous acid twice, and evaporated to dryness, then calcined for one hour in a white heat, and lastly treated with about six or eight times its weight of distilled vinegar, in a heat of about 60 degrees, for one or two hours; by this means the ponderous, calcareous, and magnesia Earths will be extracted and separated from

the argill and calx of iron, which will remain undissolved.

Of this acetous solution 100 grains should be taken and examined with the Prussian alkali, if any part be precipitated it is ponderous Earth, and by heating this to redness its weight may be known, or still better by a previous experiment, determining the quantity requisite to precipitate 1 gr. of acetous baroselenites, and by the rule of proportion, the quantity of it in the whole solution may be found.

The remainder of the acetous solution, is to be evaporated to dryness, and heated white in a clean polished iron crucible for two hours, then weighed and thrown into hot distilled water, the calcareous Earth, (if any,) will be dissolved in a sufficient quantity of this water, of which an ounce can scarcely dissolve 1 gr. so that frequent affusions of hot water may be requisite; the magnesia will remain undissolved, and is to be dried and weighed, its weight gives that of the pure calcareous Earth, from which that of the ponderous (if any) is to be deducted; the lime-water may also be precipitated by an aerated alkali.

Lastly, the argill and calx of iron, which remained undissolved by the acetous acid, are

are to be heated slightly, to prevent their cohering and reiteratedly boiled in dephlogisticated nitrous acid to dryness, and finally dissolved in that acid, which will then take up only the argill, which may be precipitated, dried and weighed; though indeed this troublesome operation may be unnecessary, as the weight of the martial part being known by the experiment, with the Prussian alkali; that of the argill is known of course, when only the two remain. This is even better, as the calx always increases in weight by these operations.

Besides this general method some others may be used in particular cases.

Thus *to discover a small proportion of argill, or magnesia, in a solution of a large quantity of calcareous Earth,* caustic volatile alkali may be applied, which will precipitate the argill or magnesia, if any be, but not the calcareous Earth. Distilled vinegar applied to the precipitate, will discover whether it be argill or magnesia.

2dly. *A minute portion of calcareous or ponderous Earth, in a solution of argill or magnesia,* may be discovered by the vitriolic acid, which precipitates the calcareous and ponderous, the solution should be dilute else the argill also

alſo would be precipitated. If there be not an exceſs of acid, the ſaccharine acid is ſtill a nicer teſt of calcareous Earth. 100 gr. of gypſum contains about 32 of calcareous Earth. 100 gr. of baroſelenite contains 84 of ponderous Earth. 100 gr. of ſaccharine ſelenite contains 45 of calcareous Earth: the inſolubility of baroſelenite in 500 times its weight of boiling water ſufficiently diſtinguiſhes it. From theſe *data* the quantities are eaſily inveſtigated.

3dly. *A minute proportion of argill in a large quantity of magneſia*, may be diſcovered either by precipitating the whole and treating it with diſtilled vinegar, or by heating the ſolution nearly to ebullition, and adding more aerated magneſia untill the ſolution is perfectly neutral, which it never is when argill is contained in it, as this requires an exceſs of acid, to keep it in ſolution. By this means the argill is precipitated in the ſtate of embryon alum which contains about ½ its weight of argill, (or for greater exactneſs it may be decompoſed by boiling it in volatil alkali.) After the precipitation the ſolution ſhould be largely diluted, as the Epſom ſalt, which remained in ſolution while hot, would precipitate when cold and mix with the embryon alum.

4thly.

4thly. A *minute portion of magneſia in a large quantity of argill* is beſt ſeparated by precipitating the whole and treating the precipitate with diſtilled vinegar.

Laſtly, *Calcareous Earth and Barytes* are ſeparated either by precipitating the barytes by the Pruſſian alkali, or the calcareous by a cauſtic fixed alkali, or by precipitating both with the vitriolic acid, and evaporating the ſolution to a ſmall compaſs, pouring off the liquor and treating the dried precipitate with 500 times its weight of boiling water; what remains undiſſolved is baroſelenite.

Table of the comparative hardneſs of different Species of Stones, extracted chiefly from the Memoirs of Stockholm, for 1768.

Mr. *Quiſt*, the author of this Memoir determined the hardneſs of moſt of the following ſtones, by obſerving the order in which they were able to cut and make an impreſſion on each other. The firſt are able to cut or ſcratch the ſucceeding, but not *vice verſa.* He added alſo the ſpecific gravity of the ſpecimens he uſed; the firſt column ſhews the hardneſs; the ſecond, the ſpecific gravity. The four laſt ſpecies I have added from my own obſervation.

Diamond

Diamond from *Ormos*,	20	
Pink Diamond,	19	3,4
Bluiſh Diamond,	19	3,3
Yellowiſh Diamond,	19	3,3
Cubic Diamond,	18	3,2
Ruby,	17	4,2
Pale Ruby from *Brazil*,	16	3,5
Spinel,	13	3,4
Deep blue Sapphire,	16	3,8
Ditto paler,	17	3,8
Topaz,	15	4,2
Whitiſh ditto,	14	3,5
Bohemian,	11	2,8
Emerald,	12	2,8
Garnet,	12	4,4
Agate,	12	2,6
Onyx,	12	2,6
Sardonyx,	12	2,6
Amethyſt,	11	2,7
Cryſtal,	11	2,6
Carnelian,	11	2,7
Green Jaſper,	11	2,7
Reddiſh yellow ditto,	9	2,6
Shoerl,	10	
Tourmaline,	10	
Quartz,	10	2,7
Opal,	10	2,6
Chryſolite,	10	3,7
Zeolyte,	8	2,1
Fluor,	7	
Calcareous Spar,	6	

Gypſum

Gypfum,	- - -	5 -
Chalk,	- - -	3 -

Remarks.

1st. Artificial gems are eafily diftinguifhed from the natural, by their foftnefs, fufibility, folubility in acids, and in many cafes by their fpecific gravity.

2dly. Stones whofe hardnefs does not exceed 11 may be fcratched by fteel.

3dly. It is remarkable that opal whofe hardnefs is equal to that of quartz, does not ftrike fire with fteel, as Mr. *Bergman* attefts, is this owing to its brittlenefs? but it feems that opals are of different degrees of hardnefs, for Mr. *Quift* in a letter to Mr. *Rinman*, mentions his having feen opals nearly as hard as diamond. *Mem. Stock.* 1766.

PART

PART II.

Saline Subſtances.

ALL thoſe ſubſtances which are known *only* by this denomination, require leſs than two hundred times their weight of boiling water to diſſolve them.

They have moſtly a peculiar taſte, and thoſe of the mineral kind are uninflammable.

CHAP. I.

Of Acids.

The *Acids* to be met with in the mineral kingdom, are the *aerial*, the *vitriolic*, the *marine*, the *ſparry*, the *ſuccinous*, *phoſphoric*, *molybdenous*, *arſenical*, and *tungſtenic*.

The *Aerial Acid* is found either in an aerial ſtate, as in mines, caverns, wells, or combined with water in mineral or common ſprings, or combined with abſorbent earths, or in ores, &c. it is eaſily known by its property of extinguiſhing lights, uniting to water, and then precipitating lime water, but not a ſolution of nitrous ſelenite.

The

The *Vitriolic* when dephlogisticated, is always united to water, and as in the Earth, it must meet with bodies with which it is capable of combining, I believe it has never been found free from all combination, though it may unite to some bodies beyond the point of saturation. It is true Mr. *Baltassari* says, he found some dry concentrated acid, adhering to selenite in a grotto in *Monte Zaccolino* near *Sienna.* 7 *Roz.* but this has been fully disproved by the subsequent observations of Mr. *Murray*, in the 37th vol. of the Memoirs of *Stockholm.* In a combined state it is found in various neutral salts.

The *phlogistigated* or sulphurous vitriolic acid, frequently occurs in a free aerial state, bursting from volcanic mountains, and also in some caverns and mineral waters.

Of the other acids, none has hitherto been found in an uncombined state, except the *sedative*, which has lately been found by Mr. *Hœffer*, dissolved in the *Laguni*, or lakes of hot mineral water near *Monte Rotundo*, *Berchiaio*, and *Castelnuovo* in *Tuscany*, in the proportion of nearly 9 grains in 100 of water. Mr. *Mascagni* has likewise found it adhering to shistus on the borders of the lakes, of a dirty white, yellow or greenish colour, and crystalized in the form of needles, 16 *Roz.* 364.

This

This Salt requires at leaſt 20 times its own weight of boiling water to diſſolve it, and 50 times its weight to keep it in ſolution. It is alſo ſóluble in hot ſpirit of wine, and this ſolution burns with a greeniſh flame. Its ſolution in water, when heated, turns that of litmus red. It vitrifies in a moderate heat, but the glaſs ſo formed is again ſoluble in water. Its ſpecific gravity is 1,479.

The *Nitrous Acid*, though generally ranked among the mineral acids, can ſcarce be called ſo, as it always requires for its formation, the putrefaction of animal or vegetable ſubſtances. It is never found diſengaged from all baſes (except perhaps in charnels and privys), but always united either to alkalis or Earths.

The Marine Acid is found only in a ſtate of combination with alkalis, earths and ſome metals.

The *Sparry* is found in fluor ſpars, lapis lazuli, chryſopraſium, and phoſphoric blende.

The *Succinous*, found only in amber.

The

The *Phoſphoric* has as yet been diſcovered only in foſſile bones, and in one ſpecies of lead ore. It probably owes its origin to the decompoſition of bones.

The *Molybdenous* acid being very lately known, has been found only in molybdena.

The *Arſenical* acid has been traced in the ores of other metallic ſubſtances, particularly of cobalt.

The *Tungſten* acid has hitherto been found only in the calcareous ſtone, called Tungſten.

CHAP. II.

Of Alkalis.

Theſe are of two ſorts, fixed and volatile; the fixed are either of vegetable or mineral origin, which differ in a few properties, but it is to be obſerved, that ſome vegetables afford alſo an alkali intirely ſimilar to that of mineral origin, particularly marine plants, or thoſe that grow near the ſea; neither of them is ever found in a cauſtic ſtate, but all are combined at leaſt with the aerial acid. They then efferveſce with moſt other acids, turn infuſions of blue flowers of certain vegetables

green, cryſtaliſe with the three ancient mineral acids, &c.

The *Vegetable Alkali* is ſeldom found in the earth, except in wells in towns, as at *Doway*, &c. 4 *Mem. Scav. Etr.* alſo in the argillaceous allum ore of *la Tolfa*, and united to the nitrous acid near the ſurface of the earth in *Spain* and the *Eaſt Indies*, probably from the putrefaction of vegetables.

The *Mineral Alkali* is not only found in a ſtate of combination with the vitriolic and marine acids, but alſo very commonly with the aerial, with which it retains, not only the name, but many of the properties of a free alkali, as the aerial acid is eaſily expelled. In this mild ſtate it is eaſily known by its cryſtalization, ſolubility in 2,5 times its weight of water, in the temperature of 60, efflorefcence by expoſure to the air, effervefcence with acids, and the properties of the different neutral Salts, reſulting from its union with the different acids, decompoſing *terreno*-neutral and ammoniacal Salts, &c.

100 Parts of this alkali, when perfectly pure and recently cryſtalized, contain according to Mr. *Bergman*, 20 of mere alkali, 16 of aerial acid, and 64 of water; my determination

termination was ſomething different from this, but then the Salt had loſt ſome of its water by expoſure to the air.

This alkali is found in *Hungary* in marſhy grounds of an argillaceous or marly nature, either mixed with earth, or cryſtalized and efflorefcing. In *Egypt* it is found at the bottom of lakes, dried up by the ſummer's heat. Alſo in the province of *Suchena*, 28 days journey from *Tripoli*, where it is called *Trona*, 35 *Mem. Stock.* alſo in *Syria*, *Perſia*, the *Eaſt Indies*, and *China*, where it is known under the name of *Kien*. It is frequently met with germinating on walls, and is by many called *Aphronitron*; alſo in many mineral waters. It is in its native ſtate frequently mixed with muriatic Earth, common ſalt, and marine Epſom, or marine ſelenite.

Volatil Alkali, in a mild ſtate, is eaſily known by its ſmell, its volatility and its action on copper, the ſolutions of which, in the mineral acids, are turned blue by it. It is frequently found, though in ſmall quantity, in mould, marl, clay, ſhiſtus, and in ſome mineral waters according to *Malouin*. *Mem. Par.* 1746. *Phil. Tranſ.* 1767. 2 *Bergm. Erde Kugel.* 304. It probably derives its origin in the mineral kingdom from

the putrefaction or combustion of animal or vegetable substances. In a caustic state it never occurs.

CHAP. III.

Of Neutral Salts.

These consist of an acid, united either to an alkali, Earth, or metal, of each of which combinations we shall treat in their order.

SPECIES I.

Tartar Vitriolate.

This is very seldom found native; Mr. *Bowles* says it is contained in some Earths in *Spain*. *Bowles Spain*, 68.

It requires about 16 times its weight of water to dissolve it in the temperature of 60, and only 5 of boiling water, it forms non deliquescent permanent crystals, decrepitates when heated, but loses but little of its weight, is of very difficult fusion, precipitates the nitrous solutions of silver, lead, mercury, and chalk, is not rendered turbid by the addition of any alkali, but the acid of tartar dropped into its solution, forms a precipitate.

100 Parts of tartar vitriolate, contain about 31 of real acid, 63 of alkali, and 6 of water.

Glauber's

Species II.

Glauber's Salts.

It is found native in ſome lakes in *Siberia*, in ſeveral mineral waters, and in the ſea, as ſome ſay; alſo in ſeveral parts of *Dauphiné* and *Lorraine* in the Earth, and ſometimes germinating on the ſurface. *Monnet Mineralogie*, 439.

Its characters are the ſame as thoſe of tartar vitriolate, except that it requires but 3 times its weight of water to diſſolve it in the temperature of 60; its cryſtals moulder by expoſure to the air, and by heat loſe half their weight. The acid of tartar cauſes no precipitation when inſtilled into its ſolution.

100 Parts of this Salt contain about 14 of real acid, 22 of alkali, and 64 of water.

Species III.

Vitriolic Ammoniac.

This is ſaid to have been found in the neighbourhood of volcanos, particularly of *Mount Veſuvius*, where, indeed, it might well have been expected; yet its exiſtence is rendered ſomewhat dubious, ſince Mr. *Bergman* could ſcarce find any trace of it among the various ſpecimens of ſalts from *Veſuvius*,

 which

which he examined, 3 *Bergm.* 236. and the reaſon probably is becauſe the vitriolic acid, diſengaged by the combuſtion of ſulphur, is in a phlogiſticated ſtate, and all its combinations in this ſtate are eaſily decompoſed by the marine acid which plentifully occurs in volcanos. It is alſo ſaid to be found in the mineral lakes of *Tuſcany*, 16 *Roz.* 363. which is much more probable, as the vitriolic acid when united to water eaſily parts with phlogiſton, and recovers its ſuperiority over other acids: alſo on the ſurface of the Earth in the neighbourhood of *Turin.*

Vitriolic Ammoniac is eaſily known: for if quick lime or fixed alkali be thrown into its ſolution, the ſmell of the volatil alkali is perceived; and if this ſolution be poured into that of chalk or ponderous Earth in the nitrous acid, a precipitate will appear. 100 parts of it contain about 42 of real acid, 40 of volatil alkali, and 18 of water.

Species IV.

Selenite.

I have already mentioned this ſubſtance among the calcareous Earths. It is frequently found in mineral and common ſprings, and alſo in ſea water. Its taſte is neither

neither bitter nor aſtringent, but earthy. Its ſolution mixes uniformly with that of nitrous or marine Selenite, but is precipitable by fixed alkalis, mild or cauſtic, and alſo by the ſaccharine acid, but not by volatile cauſtic alkali, which diſtinguiſhes it from *Epſom* and alum.

Species V.

Epſom.

Many mineral waters contain this ſalt, particularly thoſe of *Epſom*, *Egra*, *Sedlitz*, and *Seydchutz*: it has alſo been found native, mixed with common ſalt and coaly matter germinating on ſome free ſtones in coal mines. 8 *Roz.* 137.

This ſalt, in the temperature of 60, requires about its own weight of water to diſſolve it; its taſte is bitter; it effloreſces by expoſure to the air, when heated it loſes nearly ½ its weight by evaporation; its ſolution is rendered turbid by a mixture with that of nitrous or marine ſelenite, which diſtinguiſhes it from ſolutions of ſelenite, but preſerves its limpidity when mixed with a ſolution of nitrous or marine *Epſom*; its earth is precipitable by all alkalis in any ſtate, and alſo by lime.

100 parts of it contain about 24 of real acid, 19 of earth, and 57 of water.

SPECIES VI.

Alum.

Alum requires about 15 times its weight of water to diſſolve it in the temperature of 60. Its taſte is well known; it ſwells and bliſters when heated, and loſes nearly ½ its weight. It is precipitable by all alkalis, and even by magneſia, which diſtinguiſhes its baſis from that of *Epſom*: but the precipitate retains nearly ½ the weight of the acid with which it was originally united, and is in reality *Embryon Alum*; but by digeſting it in volatile alkalis (for its baſis would unite to fixed alkalis) it may be perfectly purified. Its ſolution, like that of *Epſom*, renders nitrous ſolutions of ſilver or chalk turbid, but mixes uniformly with thoſe of nitrous or marine alum, or of the vitriols of any metal: theſe properties diſtinguiſh it ſufficiently.

100 parts of it contain about 24 of acid, 18 of earth, and 58 of water.

This ſalt is found native in a few mineral ſprings *, though rarely, 1 *Bergm.* 280. and

* *Margr.* 2 *Theile*, 193.

in

in the mineral lakes of *Tuſcany*, 16 *Roz.* 362. alſo germinating on the ſurface of free ſtone or ſhiſtus in coal mines, or on lavas near volcanos, and on ſeveral rocks in the *Archipelago*, and in ſeveral parts of *Hungary*, *Bohemia*, and *Swiſſerland*, though ſeldom pure; but far the greater part of it is factitious, being extracted from various ores, the principal of which are the following:

Species VII.

Aluminous Ores.

1st. *Sulphurated Clay.* This conſtitutes the pureſt of all aluminous ores, namely, that of *La Tolfa* near *Civita Vechia*; it is white, compact, and of the hardneſs of indurated clay; hence called *Petra Aluminaris*, yet mealy and taſteleſs. Mr. *Monnet* firſt diſcovered the real nature of this ore. According to him 100 parts of it contain upwards of 40 of ſulphur, and 50 of clay, beſides a ſmall quantity of fixed vegetable alkali, and a very minute portion of iron. 13 *Roz. Supplem.* p. 338. With this Mr. *Bergman*'s analyſis nearly agrees; 100 parts of this ore containing, according to him, 43 of ſulphur, 35 of argill, and 22 of ſilex. 3 *Berg.* 271. He alſo found the vegetable alkali and iron, but probably he did not ſeparate them, but reckoned

reckoned them among the argillaceous contents, which muſt alſo have contained a quantity of vitriolic acid. To make this ore produce alum, it is neceſſary that it ſhould firſt be torrefied to decompoſe the ſulphur, whoſe acid then re-acts on the argill, and being moiſtened, or expoſed to the air, it ſoon ſwells, effloreſces, and forms alum. This ore was probably at firſt a clay, mixed with ſulphur, and hardened by volcanic fire, and derives its alkali from vegetables incinerated by the volcano. Mr. *Monnet* found alſo a little magneſia in this ore. *Mineralog.* p. 160. The red colour of the alum proceeds from iron in a particular ſtate. 3 *Bergm.* 250.

2[d.] *Pyritaceous Clay.* This is found at *Schwemſal* in *Saxony* at the depth of 10 or 12 feet; it is a black, hard, yet brittle ſubſtance, conſiſting of clay, pyrites and bitumen; after it is dug it is left expoſed to the air for two years, by which means the pyrites are decompoſed, and alum formed. 3 *Jars Voy. Metallurg.* p. 293. The alum ores of *Heſſe* and *Liege* are alſo of this ſpecies, yet they are torrefied; a practice which *Jars* condemns. According to *Monnet* this ore contains alſo magneſia. *Mineralog.* p. 164. 64 pounds of this ore yield from 5 to 7 of alum. An earth of this ſpecies, of a foliated

foliated texture, is also found in *Burgundy*, and is by some called *Ampelytes*. 1 *Chym de Dijon*. p. 107.

3^d. *Shistus Aluminaris*. This differs from roof shistus in this, that it contains a variable proportion of pyrites intimately mixed with it, and also *Petrol*. *Bergm*. *Sciagr*. and 1 *Bergm*. 292. Its colour is blue or black, but when the proportion of petrol is very small, grey. When the proportion of pyrites is so large as to form a visible mass, the ore is commonly rejected as containing too much iron, though it might be worked to advantage, by adding a proportion of clay; a valuable improvement suggested by Mr. *Bergman*. When the proportion of petrol is considerable, it does not effloresce by exposure to the air, and therefore must be torrefied to burn off the petrol, and extricate the acid from the sulphur of the pyrites; but when the proportion of petrol is small, the pyritical part is decomposed by long exposure to the air and moisture; and thus alum is formed. In *Sweden*, if 100 pounds of the ore yield 4 of alum, it is worth working; but it generally yields more. The mine of *Becket* in *Normandy*, and those of *Whitby* in *Yorkshire*, are of this species.

4th. *Volcanic Aluminous Ore*. This is found at *Solfatera* near *Naples*, and elsewhere,

where, in the form of a white ſaline earth. In this ore alum is formed by the action of the phlogiſticated vitriolic acid on argillaceous lavas.——100 parts of it contain, according to Mr. *Bergman*'s analyſis, 88 of ſiliceous earth, 4 of argillaceous, and 8 of alum; but this proportion is variable. Before eﬄoreſcence it is in a ſtony form.

5th. *Bituminous Alum Ore.* Shale. 2 *Watſon*, 314. This is a ſhiſtus impregnated with ſo much coaly matter or bitumen as to be inflammable; it alſo contains ſulphur. 120 parts of calcined ſhale afford 1 of alum; it is found in *Sweden*, and among the coal mines at *Whitehaven*, and elſewhere. 8 *Roz.* 141.

Alum might alſo be extracted from many ſpecies of pyrites, but ſo contaminated with iron as ſcarce to quit coſt; ſo alſo from calamine and pyritaceous wood.

Native alum, mixed with vitriolic ammoniac, is found cryſtalized on the borders of the mineral lakes of *Tuſcany*. 16 *Roz.* 363. it is alſo found in a capillary form near the lake of *St. Agnano*, in the grotto of *St. Germano.* 37 *Mem. Stock.*

SPECIES VIII.

Species VIII.

Vitriol of Iron.

It is of a greeniſh colour when perfectly and recently cryſtalized, but effloreſces by expoſure to the air, and becomes yellowiſh: it requires 6 times its weight of water to diſſolve it in the temperature of 60°; its acid is known by this, that the ſolution of this ſalt mixes without turbidity with the ſolutions of other ſalts that contain the vitriolic acid, as Epſom, ſelenite, tartar vitriolate, &c. but renders the ſolutions of nitrous or marine ſelenite turbid; and its baſis, by the black colour which the ſolution of galls or vegetable aſtringents immediately produce in its ſolution.

100 Parts of it recently cryſtalized contain 20 of real acid, 25 of iron and 55 of water.

It is frequently found native, either in coal mines, or in the cavities of pyritaceous mines, or adhering to the ſcaffolds in a ſtalactitical form. Alſo in ſmall round ſtones called *Ink* ſtones, of a white, red, grey, yellow or black colour, which are almoſt intirely ſoluble in water, and contain a portion of copper and zinc. 2 *Schlutter*, 620. 2 *Jars*, 265. Alſo ſometimes in ſhiſtus. But the greateſt part

part of that in ufe is prepared from the martial pyrites or mundic.

Martial Pyrites is an iron ore containing from $\frac{1}{6}$ to $\frac{1}{3}$ of fulphur, from $\frac{1}{8}$ to $\frac{5}{8}$ of iron, the remainder argill and filex, the three firft intimately combined with each other, and the iron in a femiphlogifticated ftate. *Monnet Eaux Miner.* 281. 2 *Gerh. Beytr.* 57. It ftrikes fire with fteel, and thence derives its name; it is generally of a yellow or grey colour, of a globular or cubic fhape, internally radiated and fometimes lamellar, commonly in part foluble in nitrous acid with effervefcence, and flowly in the vitriolic, with which it forms alum; it detonnates flightly with nitre and is very infufible: its fpecific gravity is from 3,7 to 4,912. Some pyrites inftead of argillaceous contain calcareous Earth, thefe are common in *France*, and in them the iron is in a dephlogifticated ftate. *Monnet Mineral.* 339. Pyrites are frequently found in a ftatactical fhape, and often form the matter of petrifactions: they are alfo found mixed and interfperfed through almoft every other fpecies of ftone except granite. According to Mr. *Monnet*, thofe of a filamentous or ftriated texture contain leaft fulphur, thofe of a lamellar, moft; the laft efflorefce difficultly if at all, and are faid to contain from 25 to 35 per cent of fulphur.

Vitriol

Vitriol is formed in theſe ſtones by expoſing them a long time to the action of the air and moiſture, or by torrefaction in open air, and ſubſequent expoſition to its action, which operation in ſome caſes muſt be often repeated, according to the proportion of ſulphur, and the nature of the Earth; the calcareous pyrites are thoſe in which it is moſt eaſily formed, and they effloreſce the ſooneſt, good pyrites properly treated, yield about $\frac{2}{3}$ of their weight of vitriol.

Vitriol is alſo prepared from mineral waters that hold copper in ſolution, which is precipitated by iron; this ſolution of iron is afterwards cryſtalized and always retains ſome copper. In *Hungary* it is prepared from pyritaceous ſhiſtus, and in many places from a ſpecies of calamine; the vitriol of goſlaar commonly contains a portion of zinc, as that of *Hungary* and *Saxony* does of copper; the Engliſh and French vitriols are purer, yet ſometimes contain a ſmall proportion of alum. Turf and peat are ſometimes impregnated with vitriol; other earths alſo often contain vitriol and alum. *Mon. Mineral.* 460. This vitriol is ſometimes found of a white colour on the borders of the mineral lakes of *Tuſcany*. 16 *Roz.* 363.

SPECIES IX.

SPECIES IX.

Vitriol of Copper.

Its colour is blue, which degenerates into a mixture of blue and rufty yellow after it has been long expofed to the air; it requires about four times its weight of water to diffolve it in the temperature of 60. Its fpecific gravity is about 2,23; if a piece of clean polifhed iron be dipped into the folution of this falt, it will almoft immediately be covered with a cupreous coat, this together with the deep blue colour arifing from mixing it with a volatile alkali, difcovers its bafis, as its uniform mixture with other vitriolic falts does its acid.

100 Parts of vitriol of copper contain 30 of real acid, 27 of copper, and 43 of water. 80 Parts of good iron precipitate 100 of copper, from a folution, that does not contain a notable excefs of acid.

This falt rarely occurs cryftalized, but is often found naturally diffolved in water, in *Hungary, Sweden and Ireland*: from this water blue vitriol is generally prepared. Mr. *Cronfted* fays it is feldom free from iron and zinc; it is alfo occafionally extracted from fulphurated copper ores after torrefaction. *Schlutt.*

Schlutt. 638. According to Mr. *Cronſted*, the blue vitriol of *Goſlaar* contains a mixture of zinc.

Species X.
Vitriol of Zinc.

Its colour is white, it requires little more than twice its weight of water to diſſolve it in the temperature of 60; its ſpecific gravity is about 2,000; it mixes uniformly with vitriolic neutral ſalts, but precipitates nitrous or marine ſelenites from their ſolutions, which aſcertains its acid principle; it is itſelf precipitated whitiſh by alkalis and earths, but not by iron, copper, or zinc, which ſufficiently indicates its baſis; if it contains any other metallic principle, this may be precipitated by adding more zinc, except iron, which will of itſelf precipitate by expoſure to the air, or boiling in open air.

100 parts of vitriol of zinc, contain 22 acid, 20 of zinc, and 58 of water.

This ſalt is ſometimes found native, mixed with vitriol of iron, and in the form of white hairy cryſtals, 2 *Linné von Gmelin*, p. 316, or in a ſtalactitical form in the galleries of Mines in *Hungary*, *Goſlaar*, &c. or as an efflorefcence on ores of zinc; it is alſo found diſſolved in mineral waters, and generally with ſome proportion of the vitriols of iron and copper, 2 *Bergm.*

 318,

318, but that in common uſe is moſtly prepared at *Goſlaar* from an ore which contains zinc, copper, and lead, mineralized by ſulphur and a little iron; the copper ore is firſt ſeparated as much as poſſible, and the reſiduum after torrefaction and diſtillation is thrown red hot into water and lixiviated. *Schlutt*, 639, 3 *Jars*, 320, it is never free from iron.

The vitriols of copper, iron, and zinc, are according to Mr. *Cronſted*, frequently found mixed in the waters pumped out of mines, ſometimes all three are found cryſtalized in lumps of a yellow colour; the vitriol of *Fahlun* in *Sweden*, contains all three, *Bergm. Sciagr.* § 82.

Species XI.

Vitriol of Cobalt.

It is difficultly ſoluble in water, and both it and its ſolution are red, which ſufficiently diſtinguiſhes its baſis; its acid is known by the ſame teſts as that of the former vitriols.

It is ſaid to be found native in ſmall pieces, mixed with a greeniſh effloreſcence in cobalt mines, *Born, Index, Foſſ.* 51.

Halotrichium

Halotrichium, *Trichites*, or native alum mixed with vitriol of cobalt, is found in a capillary form in mines of gold, ſilver, and mercury, in *Hungary* and *Germany*. 2 *Lin. von. Gmelin* 316. the phlogiſticated alkali, precipitates the cobalt which with borax gives an azure glaſs. 2 *Bergm.* 455.

SPECIES XII.

Vitriol of Nickel.

This is alſo difficultly ſoluble in water; both it and its ſolution are of a green colour; it is found native efflorеſceing on *Kupfernickel* and generally mixed with vitriol of iron; 1 *Mem. Sued.* 213. *Cronſt.* § 123. zinc precipitates the nickel, but not the iron.

SPECIES XIII.

Vitriol of Manganeſe.

I do not know that this has been as yet found; as its colour and alſo that of its precipitate by fixed alkalis, is white, it may be confounded with vitriol of zinc; but the precipitate of the vitriol of manganeſe ſoon grows black by expoſure to the air, eſpecially if heated, and is then inſoluble in the dephlogiſticated nitrous acid, unleſs ſugar be added, properties which the precipitate of zinc does not poſſeſs.

SPECIES XIV.

Vitriols of Silver, Mercury and Lead.

Theſe I ſhall treat of among the ores of thoſe metals.

SPECIES XV.

Nitre, or Priſmatic Nitre.

Nitre requires about 7 times its weight of water to diſſolve it in the temperature of 60: its ſpecific gravity is 1,92, vegetable alkalis do not render its ſolution turbid, but the acid of tartar does; it deflagrates with burning coals, or on a red hot iron, and mixed with marine acid it makes *aqua regia.*

100 Parts of nitre contain about 30 acid, 63 vegetable alkali, and 7 of water.

It is ſaid to be found formed by nature in certain clays in the *Eaſt Indies, China, Spain,** and in *Siberia,* in the cavities of rocks,† alſo on the ſurface of maſſes of chalk, in the neighbourhood of *Rocheguyon,* ‡ and in ſome wells in great towns, as London and Berlin; but more frequently in old mortar, § ſome-

* 1 Watſon, 315, Bowls, *Spain,* 70, 78, Suenſk. Handſ. 1772. 2 Quart. † Phil. tranſ. 1763, p. 209. ‡ Macq. Dict. *Nitre.* § 1 Wats. 293.

times

times it ſhoots on the ſurface of damp walls, and is then called *ſalpetère de houſſage*. *Mon. Mineral*, 446, but Mr. *Lavoiſier* has ſhewn that old mortar often contains only nitrous ſelenite, which is converted into true nitre by mixture with aſhes, though thoſe aſhes contain a large proportion of tartar vitriolate and glauber's ſalt, becauſe theſe ſalts decompoſe the calcareous ſelenite, and form nitre by the way of double decompoſition, *Mem. Par.* 1777.

Species XVI.

Cubic Nitre.

This ſalt requires but 3 times its weight of water to diſſolve it, at the temperature of 60; its ſpecific gravity is about 1,87; vegetable fixed alkali decompoſes it without forming a viſible precipitate in its ſolution, neither does the tartarous acid precipitate any thing from it; with vitriolic acid (the nitrous being expelled) it forms glauber's ſalt; it deflagrates like priſmatic nitre, and alſo forms *aqua regia*, in the ſame circumſtances.

100 Parts of cubic nitre contain about 29 of real acid, 50 of mineral alkali, and 21 of water.

According to Mr. Bowles, it is found native in *Spain*.

Species XVII.

Nitrous Ammoniac.

It generally deliquefces; when mixed with a fixed alkali, the volatile betrays itfelf by its fmell; it deflagrates when the containing veffel is heated nearly red; with fpirit of falt it makes *aqua regia.*

100 Parts of it contain 46 of nitrous acid, 40 of volatile alkali, and 14 of water, as I believe.

It is frequently found in the mother liquor of nitre, *Linné von Gmelin*, 332, *Weber Abhand, von den Salpetre*, 17.

Species XVIII.

Nitrous Selenite.

This alfo deliquefces, its tafte is bitter, fixed alkalis decompofe it, and form cubic or prifmatic nitre, but cauftic volatile alkali cannot decompofe it, it does not deflagrate, yet paper moiftened with a faturate folution of it, crackles on burning, it lofes its acid in a ftrong red heat, its folution will not trouble that of filver in the nitrous acid; vitriolic acid will precipitate its bafis, as will the acid of fugar.

100 parts of it contain, when well dried, about 33 of acid, 32 of calcareous earth, and 35 of water.

It exifts in old mortar, and the mother liquor of nitre; alfo in chalk rocks near *Rocheguyon*. *Macquer's Dict. Nitre.*

SPECIES XIX.

Nitrous Epfom

Deliquefces, does not deflagrate, does not render the nitrous folution of filver turbid, is precipitated by cauftic volatil alkali, and alfo by the acid of fugar, but the precipitation is fcarce apparent, unlefs fpirit of wine or evaporation be applied. If nitrous felenite and nitrous *Epfom* be mixed, and both folutions be faturated, a precipitate will alfo appear; neither vitriolic acid nor mild magnefia occafion any turbidity in its folution.

100 parts of it contain about 36 of real acid, 27 of magnefia, and 37 of water.

It exifts in old mortar, and is found in the mother liquor of nitre.

SPECIES XX.

Salt of Sylvius

Requires about 3 times its weight of water to diſſolve it; its ſpecific gravity is 1,836; diſſolved in nitrous acid it makes *aqua regia*; it forms a cloud in the nitrous ſolution of ſilver; fixed alkali precipitate nothing from its ſolution, nor does a mixture of marine ſelentine, but the acid of tartar cauſes a precipitate.

100 parts of it contain about 30 of real acid, 63 of vegetable alkali, and 7 of water.

It is found in ſome boggs in *Picardy*, and ſome mineral waters in *Normandy*. *Monnet Hydrolog*. 263.

SPECIES XXI.

Common Salt

Requires about 2,5 its weight of water to diſſolve it in the temperature of 60; its ſpecific gravity is 2,12; the acid of tartar precipitates nothing from it; in other reſpects it agrees with the above.

100 parts of it contain 33 real acid, 50 of mineral alkali, and 17 of water.

It

It is not only found in the ſea, ſalt lakes, and many ſalt ſprings in the proportion of even 36 per cent. but alſo in large maſſes under the earth in many countries, as *Poland*, *England*, *Tyrole*, &c. alſo in coal and beds of gypſum. *Born's Index*. Its colour is either grey, red, blue, yellow or black. *Cronſted* §. 129. *Born.*

SECTION XXII.

Sal Ammoniac

Requires about 3,5 times its weight of water to diſſolve it in the temperature of 60; its ſpecific gravity about 1,42; it makes *aqua regia* when mixed with nitrous acid; it diſſolves copper; it wholly evaporates when laid on a hot iron.

100 parts of it contain 52 of real acid, 40 of volatil alkali, and 8 of water.

It is found native and of different colours, grey, black, green, red, in the neighbourhood of volcanos, and in the mineral lakes of *Tuſcany*. 16 *Roz*. 362. Alſo in ſome mountains of *Tartary* and *Thibet*. 2 *Linné von Gmelin*. 335. and in the caverns or grottos of *Pouzzoli*. *Mem. Sued*. 243. alſo in various clays, though in ſmall quantity. *Ibid.*

Species XXIII.

Marine Barofelenite.

This confifts of marine acid united to barytes; it is faid to have been found in fome mineral waters in *Sweden. Bergm. Sciagr.* §. 58. It is known by its eafy precipitability by the vitriolic acid, and the great infolubility and weight of the refulting compound.

Species XXIV.

Marine Selenite

Deliquefces; its bafis is alfo precipitable by the vitriolic acid, and its folution renders that of filver in the nitrous acid turbid, at the fame time that it makes no change in that of nitrous felenite; it obftinately retains its acid in a red heat.

100 parts of it contain, when well dried, about 42 of acid, 38 of earth, and 20 of water.

It is frequently found in mineral waters, *Monnet*, 457, and fometimes in fea water, *Cronft.* §. 128. *Mon. Hydrol*, p. 206, 294, but not always, 1 *Bergm.* 192, probably only where the bottom of the fea is calcareous, alfo

alſo in the ſalt works at *Salſburgh. Born. Index* 52.

SPECIES XXV.

Marine Epſom

Alſo deliqueſces; its ſolution does not trouble that of nitrous or marine ſelenite, but it cauſes a cloud in the nitrous ſolution of ſilver; vitriolic acid makes no viſible precipitate in its ſolution; but all alkalis, even the cauſtic volatil alkali, precipitate its baſis; it loſes its acid in a red heat.

It is found in the ſea in greater plenty than any other ſalt, exept ſea ſalt. 1 *Bergm.* 182.

SPECIES XXVI.

Marine Alum.

This ſalt has not yet been found; if it exiſts, it may be known by its deliqueſcence and precipitability by magneſia, pure or mild; the mild ſhould preferably be uſed, as it is moſt ſoluble.

SPECIES XXVII.

Species XXVII.

Marine Salt of Copper.

This has been found in *Saxony* in the mine of *Johngeorgenſtadt*; it is of a greeniſh colour and foliated texture, moderately hard, and ſometimes tranſparent and cryſtalized; it has been taken for a ſort of mica, but Mr. *Bergman* found it to conſiſt of copper and marine acid, with a little argillaceous earth. 2 *Bergm.* 431. Another ſpecimen of a purer ſort, and bluiſh green colour, was alſo depoſited in the muſeum of *Upſal*. *Ibid.*

Species XXVIII.

Marine Salt of Mangane∫e.

Mr. *Hielm* is the only perſon who has as yet found this ſalt; he diſcovered it in ſome mineral waters in *Sweden*; it is precipitated of a whitiſh yellow colour by the *Pruſſian* alkali, and of a browniſh yellow by the mineral alkali; it does not cryſtalize in any diſtinct form, but attracts the moiſture of the air; to obtain it free from iron, it ſhould be precipitated by the mineral alkali, rediſſolved in nitrous acid, then calcined until this acid is expelled, and the reſiduum treated with

with diftilled vinegar, which will then take up only the manganefe.

Species XXIX.

Marine Salt of Mercury.

See mercurial ores, Species III.

Species XXX.

Borax.

In the ftate in which it is naturally found requires about 18 times its weight of water to diffolve it in the temperature of 60; its fpecific gravity is about 1,74; it does not effervefce with the mineral acids, except they be heated, and then but flightly; when heated, it fwells and lofes $\frac{4}{10}$ of its weight, and in a ftronger heat runs into a glafs, which is rediffoluble in water.

If to a faturate folution of borax, oil of vitriol be added until it becomes fenfibly acid, the fedative falt will feparate from the borax, and fwim on the furface in the form of white fcales, the filtered liquor will on evaporation yield *Glauber's* falt.

100 parts of purified borax contain 34 of real fedative acid, 17 of mineral alkali, and 47 of

of water, but of the mineral alkali only about 5 parts are really ſaturated, the reſt is unſaturated; and hence in many caſes borax acts as an alkali.

Borax comes to Europe from the *Eaſt Indies* in a very impure ſtate in the form of large, flat hexangular or irregular cryſtals, of a dull white r greeniſh colour, greaſy to the touch, or in ſmall cryſtals, as it were cemented together by a rancid, yellowiſh, oily ſubſtance, intermixed with marl, gravel, and other impurities. In this ſtate it is called brute borax, *chryſocolla* or *tincal.*

It is purified by ſolution, filtration and cryſtaliſation; and the cryſtals thus obtained are calcined to free them ſtill further from greaſineſs, and then diſſolved, filtered, and cryſtalized a 2d time; ſometimes more mineral alkali is added, as it is ſaid that tincal contains an exceſs of ſedative ſalt.

It has been long thought that borax was a factitious ſubſtance, but it is now beyond all doubt that it is a natural production, ſince Mr. *Grill Abrahamſon* ſent ſome to *Sweden* in the year 1772 in a cryſtaline form as dug out of the earth in the kingdom of *Thebet*, where it is called *pounxa*, *my poun* and *houi poun*; as borax is purified alſo in the *Eaſt Indies*, Mr. *Engeſtrom*

Engestrom suspects that the tincal is only the residuum of the mother liquor of borax evaporated to dryness, and that the greasiness arises from its being mixed with butter milk to prevent its efflorescence. It is said to have been found in *Saxony* in some coal pits. *Gerh. Beytr.* 144.

PART

PART III.

Inflammables.

UNDER this head I do not comprife *all* minerals that may be inflamed if expofed to a ftrong heat, for otherwife feveral fulphureous metallic ores, pyrites, and even fome metallic fubftances, diamonds and plumbago, fhould be arranged under this clafs, which would occafion that confufion which is meant to be avoided by fyftematic claffification, but merely thofe fubftances, which in fact are inflammable, and do not come under the denomination of Earths, Salts, or metallic ores, and have general characters perfectly diftinct from them. Of thefe fome are fluid, fome liquid, and fome folid; the fpecific gravity of the latter never exceeds 2,5, and the former are the lighteft of all bodies. The French beftow the name of *Bitumen* upon all liquid and folid mineral inflammables, except fulphur; the Germans by that name denote only the folid. Thefe are all, except coal, electrics, *per fe*, and infoluble in water and fpirit of wine, but foluble in fome fpecies of oil. Mr. *Bergman* fays he poffeffes a concrete rape-feed oil, which is hard and pellucid like copal, and infoluble in water and fpirit of wine. 2 *Erde. Befchr.* 267.

SPECIES I.

Species I.

Inflammable Air, Fire Damp.

This is eaſily known by its property of inflaming, when mixed with twice or thrice its bulk of common atmoſpheric air. When pure, it explodes all at once, but when mixed or combined with fixed air, it burns with a blue lambent flame. It frequently occurs in coal-pits and mines, and often on the ſurface of ſprings in *Perſia*, *Italy*, and *France*, and ſeems to be nothing more than the exhalation of petrol.

Species II.

Hepatic Air.

This air ſeems to conſiſt of ſulphur, held in ſolution in vitriolic or marine air; it is inflammable when mixed with $\frac{3}{4}$ of its bulk of common air. Water will take up about $\frac{1}{2}$ its bulk of this air, and when ſaturated with it will turn ſilver black, but if ſtrong dephlogiſticated nitrous acid be dropped into this water, the ſulphur will be precipitated.

100 Cubic inches of this air, when united to water, may hold 8 grains of ſulphur in

 ſolution,

ſolution, in the temperature of 60, and more if hotter. Pure air alſo decompoſes hepatic air.

It is found in many mineral waters, and particularly in the hot baths of *Aix la Chapelle*. The cauſe and manner of their containing ſulphur, which was long a problem, has at laſt been happily explained by Mr. *Bergman*. It plentifully occurs in the neighbourhood of volcanos, and in ſeveral mines.

Species III.

Naphtha.

A fine thin fragrant colourleſs oil, which iſſues out of white, yellow, or black clays in *Perſia* and *Media*, is known by this name. It burns with a bluiſh yellow flame, and is as inflammable as æther, and like it, extracts gold from *Aqua Regia*. It is not decompoſed by diſtillation, and yet if long expoſed to the air, it changes colour, thickens, and degenerates into petrol. Its ſmell is very different from that of vegetable oils; it diſſolves reſins and balſams, but not gum reſins, nor elaſtic gum. It diſſolves the eſſential oils of thyme and lavender, but is inſoluble in ſpirit of wine and æther. Its ſpecific gravity is 0,708.

SPECIES IV.

Petrol, Bergoel, Steinoel.

Doctor *Priestley* has shewn in the 3d volume of his Obſervations and Experiments on Air, that eſſential oils, long expoſed to the atmoſphere, abſorb not only the pure part, but alſo the phlogiſticated part of it. An abſorption, which muſt, in time, produce conſiderable changes in them; by a proceſs of this ſort, naptha is converted into petrol, which is an oil of various degrees of denſity, according to the time during which it has been expoſed to the atmoſphere; its colour is reddiſh, or yellow, brown, greeniſh, or blackiſh, it is found trickling from rocks, or iſſuing from the earth in the Dutchy of *Modena*, and in various parts of *France*, *Swiſſerland*, *Germany*, and *Scotland*, as well as in *Aſia*. Alſo on the ſurface of the water of different fountains, or mixed with earth and ſand, from which it is ſeparated by infuſion in water; the thinneſt ſort poſſeſſes the properties of naphtha, though in a leſſer degree. It is rendered finer by diſtillation with water, and leaves a reſinous reſiduum, and if diſtilled with a volatil alkali, the alkali acquires the properties of ſuccinated ammoniac, and hence contains the acid of amber. Some ſorts of it, according to *Monet*, are nearly

of the denſity of nut oil. It is inſoluble in ſpirit of wine.

SPECIES V.

Barbadoes tar, Erdepech, Bergtheer, Kedria-terreſtris, Maltha.

Petrol long expoſed to the air, forms this ſubſtance. It is of a viſcid conſiſtence, of a brown, black, or reddiſh black colour, ſometimes inodorous, but generally of a more or leſs diſagreeable ſmell, particularly when burned. It eaſily melts, and burns with much ſmoke and ſoot, and leaves either aſhes or a ſlag, proceeding from heterogeneities contained in it. Spirit of wine cannot diſſolve it. It contains a portion of the ſuccinous acid, for with mineral alkali it gives a bitter ſalt, more difficultly ſoluble than common ſalt, and which treated with charcoal, will not afford ſulphur. *Mem. Berlin*, 1758.

It is found in *Perſia*, in the neighbourhood of *Petrol*, in ſtrata of gypſum and limeſtone, or floating on water, alſo in *Siberia, Germany, Switzerland*, and in coal-pits, alſo in *America.*

SPECIES

Species VI.

Asphaltum, Iudenpech, Berghartz, Steinpech, Erhartete Bergtheer.

This is a ſmooth, hard, brittle, inodorous black or brown ſubſtance; it breaks with a ſmooth ſhining ſurface, melts eaſily when heated, and when pure, burns without leaving any aſhes, but if impure, leaves aſhes or a ſlag. According to Mr. *Monnet*, it contains ſulphur, or at leaſt the vitriolic acid, which ſeems confirmed by the experiments of Meſſrs. *Gerhard** and *Thory*,† it is ſlightly and partially acted on by Alcohol and æther.

It is found on the ſhores of the Red Sea, alſo in *Sweden*, *Germany*, and *France*.

Species VII.

Mineral tallow, Mumia, Beleſſoon.

This was found in the ſea on the coaſts of *Finland*, in the year 1736; it is perfectly white, and of the conſiſtence of tallow, but more brittle, though as greaſy. Its ſpecific gravity is 0,770, whereas, that of tallow is 0,969; it burns with a blue flame, and a ſmell of greaſe, leaving a black viſcid matter, which is more difficultly conſumed, it is ſoluble in ſpirit of wine only when tartariſed, and even

* 2 Beytrage. † 6 Crell Chemiſche Journal, p. 67.

then leaves an insoluble residuum, but expressed oils dissolve it when boiling. It is also found in some rocky parts of *Persia*, but seems mixed with petrol, and is there called *Schebennaad*, *Tsienpen*, *Kodreti*.* Mr. *Herman*, a physician of *Strasburgh*, mentions a spring in the neighbourhood of that city, which contains a substance of this sort diffused through it, which separates on ebullition, and may then be collected. 3 *Roz.* 346.

Species VIII.

Jet, Gagates, Lapis Obsidianus.

Jet is much harder than asphaltum, always black, susceptible of a good polish and glassy in its fracture, which is conchoidal; it is highly electrical; its specific gravity is 1,744; it melts in a moderately strong heat with a disagreeable smell, when burnt it leaves a grey earthy ochrous residuum; it is insoluble in spirit of wine.

It is found in *England*, *Scotland*, *France*, *Italy*, *Germany*, *&c.*

Species IX.

Pitt or Stone Coal. Lithanthrax.

Coal is a black, solid, compact, brittle, inflammable substance, of a moderate hardness,

* *Mem. Sued.* 87. 2 *Lin. von Gmel.* 389. 2 *Gerb. Beytr.* 211.

laminated

laminated texture, more or less shining, but rarely susceptible of a good polish, does not melt when heated, and always leaves some ashes; it seems to consist of petrol or asphaltum intimately mixed with a small proportion of Earth, mostly argillaceous, seldom calcareous, and often with pyrites; according to Mr. *Gerhard*, spirit of wine extracts a red colour from it, caustic fixed alkali attacks the bituminous part, and fat oils act on and form a varnish, at least with some sorts of it: a fixed alkali has never been found in it, nor any sulphur, except it contained pyrites. Four varieties of it deserve to be distinctly considered: none of them are electrics *per se*.

I. *and* II. Variety.

Cannel Coal, and Killkenny Coal.

Cannel coal is of a dull black colour, breaks easily in any direction, and in its fracture presents a smooth conchoidal surface, if broken transversly: this sort contains most petrol and in a less dense state; hence it burns with a bright lively flame: its specific gravity is about 1,27; *Killkenny* coal contains the largest proportion of dense petrol or asphaltum: and hence burns with less flame and smoke, and more slowly though intensely, the quantity of Earth in this coal does not exceed $\frac{1}{20}$ of its weight: its specific

gravity is about 1,4, it is frequently mixed with pyrites.

III. Variety.

Coal containing a moderate proportion of Petrol and Bitumen.

This burns with more or lefs flame according to the proportion of petrol; in its fracture, it prefents a rougher furface than *Cannel* coal: its fpecific gravity is from 1,3 to 1,37; the beft coal is of this fort, by diftillation it affords firft fixed air, then an acid liquor, afterwards inflammable air, and a light oil of the nature of petrol, then a volatil alkali, and laftly a denfe pitchy oil; the refiduum is nearly $\frac{3}{4}$ of the whole, and being flowly burnt, affords 13 per cent. of afhes, which is moftly argillaceous Earth, of which $\frac{3}{100}$ or thereabouts is magnetic. *Mem. Stock.* 1781.

100 Parts of this coal contain about 17 of Earth, of which 4 are martial; hence we fee that coal does not confift of a fhiftus penetrated with petrol, as many have thought, for then a large proportion of filex, magnefia, and calcareous earth fhould be found in it.

IV. Variety.

IV. Variety.

Sulphureous Coal.

This confifts of the former mixed with a notable proportion of pyrites: hence it is apt to moulder and break when expofed to the air, and contains yellow fpots that look like metal; it burns with a fulphureous fmell, and leaves red afhes, or a flag; water acts upon it after it has mouldered: its fpecific gravity is 1,5, or more.

Befides thefe varieties, fhiftus, micaceous fhiftus, and gneifs are frequently found in the neighbourhood of coal-mines fo penetrated with petrol or bitumen as to conftitute an inferior fpecies of coal, but the bitumen being burnt, they preferve their form, and in fome meafure their hardnefs; I have alfo feen grey flates fo foft as to be fcraped with the nail, and which were greafy to the touch, that burned like coal.

All the different fpecies of coal arife from a mixture of the varieties here enumerated.

Note. That wherever coals exift, flates are found near them, and falt or mineral fprings often in their neighbourhood.

SPECIES X.

Bovey Coal, Taub Kohle. Xylanthrax.

This is of a brown, or browniſh black colour, and lamellar texture, the laminæ are frequently flexible when firſt dug, though generally they harden when expoſed to the air; it conſiſts of wood penetrated with petrol or bitumen, and frequently contains pyrites, alum, and vitriol; its aſhes afford a ſmall quantity of fixed alkali, according to the German chymiſts; * but according to Mr. *Mills* they contain none; † by diſtillation it yields an ill ſmelling liquor, mixed with volatil alkali and oil, part of which is ſoluble in ſpirit of wine, and part inſoluble being of a mineral nature.

It is found in *England*, *France*, *Italy*, *Swiſſerland*, *Germany*, *Iceland*, *&c.*

SPECIES XI.

Peat Geanthrax.

There are two ſorts of inflammable ſubſtances known by this name; the firſt and principal is of a brown, yellowiſh brown, or black colour, found in moory grounds, and

* 2 *Gerb. Beytr.* 271. † *Phil. Trans.* 1760.

and when fresh of a viscid consistence, but hardens by exposure to the air; it consists of clay, mixed with calcareous earth and pyrites, and sometimes contains common salt; while soft it is formed into oblong pieces, and the pyritaceous and stony matters are separated; when distilled it affords water, acid, oil and volatil alkali, and its ashes contain a small proportion of fixed alkali; they are either white or red according as it contains more or less ochre or pyrites. 2 *Ed. Essays*, 244. 2 *Gerh. Beytr.* 265. It is found in *Scotland*, *Holland*, and *Germany*. Another sort is found near *Newbury* in *Berkshire*; it contains but little earth, but consists chiefly of wood branches, twiggs, roots of trees, with leaves, grass, straw and weeds. *Phil. Trans.* 1757. p. 110.

Species XII.

Turf.

This consists of mould interwoven with the roots of vegetables; when these roots are of the bulbous kind, or in large proportion, they form the looser and worst kind of turf; but when mixed with a considerable proportion of peat, they form what is called *stone turf*; it at first hardens, but at last crumbles by long exposure to the air.

Species XIII.

Species XIII.

Amber, Bernſtein, Agtſtein, Succinum, Electrum, Carabé.

Amber is a hard, brittle, taſteleſs ſubſtance, ſometimes perfectly tranſparent, but moſtly ſemi-tranſparent or opake, and of a gloſſy ſurface; it is found of all colours, but chiefly yellow or orange, and often contains leaves or inſects; its ſpecific gravity is from 1,065 to 1,100; its fracture is even, ſmooth and gloſſy; it is capable of a fine poliſh, and becomes electric by friction; when rubbed or heated, it gives a peculiar agreeable ſmell, particularly when it melts, that is, at 550 of *Fahrenheit*, but it then loſes its tranſparency; projected on burning coals, it burns with a whitiſh flame, and a whitiſh yellow ſmoke, but gives very little ſoot, and leaves browniſh aſhes; it is inſoluble in water and ſpirit of wine, though this latter when highly rectified extracts a reddiſh colour from it, but it is ſoluble in the vitriolic acid, which then acquires a reddiſh purple colour, and is precipitable from it by water; no other acid diſſolves it; nor is it ſoluble in fixed alkalis, nor in eſſential oils, nor in expreſſed, without ſome decompoſition, and long digeſtion; but balſams diſſolve it readily; 75 gr. of it alkaliſe 100 of nitre,

nitre, and therefore 100 gr. of it contain nearly 90 of phlogiston; by distillation it affords a small quantity of water, an oil of the nature of petrol, and a peculiar acid called the succinous acid. *Stockar*, p. 1, 11, 17, &c. According to *Baumer Reg. Men.* 22. 100 gr. of amber afford about 72 of petrol, and 4,5 of salt, that is, succinous acid; the remainder was fixed, or water.

It is found in masses of different sizes in several pits in *Germany*, particularly in *Prussia*, but the best sort is that which is taken out of, or cast on shore by the sea. According to Mr. *Scheele* amber yields by distillation an aqueous acid, which possesses all the properties of vinegar; if so, it is probably of vegetable origin. *Scheff. Forles.* §. 68. 1 *Anmerk.*

Ambergris, Ambra.

This is a grey, brown, yellowish, black or brown substance, of the consistence of wax, and an agreeable smell, lighter than water, and easily inflammable, cast up by the sea on the coasts of *Madagascar*, *Coromandel*, &c. but as Dr. *Swediar* has lately proved it to be of animal origin, I shall take no further notice of it.

Copal.

Mr. *Lehman* and many others rank this alſo among minerals; but Mr. *Bloch*, in a ſtill later diſſertation, has ſatisfactorily proved that it belongs to the vegetable kingdom. 2 *Beſchaft. Berl. Geſellſch.* p. 91.

SPECIES XIV.

Sulphur, Brimſtone.

Sulphur is a taſteleſs, hard, brittle, idio-electric ſubſtance, of a yellow or greeniſh yellow colour, whoſe ſpecific gravity is from 1,9 to 2,35. According to Mr. *Bergman* it gently evaporates at 170, melts at 185, and flames at 302 of *Fahrenheit*. 3 *Bergm.* 242. It burns with a blue flame, and a diſagreeable ſuffocating ſmell; in cloſe veſſels it ſublimes without decompoſition, or only a decompoſition proportionable to the quantity of air they contain; when melted it becomes red, but recovers its colour on cooling.

It is inſoluble in water, though by long trituration it is ſaid water will take up ſome of it, but I believe it is rather diffuſed thro' than diſſolved in it; neither can ſpirit of wine unite to it, except when both are in a vaporous ſtate, and then 72 parts of ſpirit of wine

wine take up 1 of sulphur; it is soluble in hot oils, and also in fixed alkalis both in the dry and liquid way; it is decomposed by boiling in concentrated nitrous acid, partly decomposed and partly dissolved by the vitriolic, and dephlogisticated marine acid; it consists of vitriolic acid and phlogiston united nearly in the proportion of 3 to 2; for 100 gr. of sulphur contain about 60 of acid, and 40 of phlogiston.

It is found native either in solid pieces of indeterminate shape, running in veins thro' rocks, or in small lumps in gypsums and lime stones, and in considerable quantity in *solfatera* and the neighbourhood of volcanos, or crystalized in pale, transparent or semi-transparent, octagonal or rhomboidal crystals, in the cavities of quartz, and particularly in the matrixes of ores, or in the form of small needles over hot springs, or near volcanos, and sometimes in old privies.

2dly. *United with clay*, as in the aluminous ore of *la Tolfa*, and also at *Tarnowitz* in *Silesia*. The former has been already described, the latter is a light grey earth, which when dry bursts in water like marl, possesses a strong peculiar smell like camphor. If it be distilled, some sulphur sublimes.

100 gr. of this earth afford 8 of ſulphur, beſides gypſum, and a ſmall quantity of iron. *Mem. Berl.* 1757.

3dly. *Mixed with clay, iron and ſelenite.* This compound is of a grey, brown or black colour, found near *Rome*, in *Auvergne*, *Spain* and *Iceland*. 2 *Lin. von. Gmelin.* 447.

4^thly. *United to lime-ſtone*, in the form of a calcareous hepar. This is found at *Tivoli* near *Rome*, and elſewhere in *Italy*. *Mem. Par.* 1770, p. 6. or diſſolved in mineral waters; 3 pounds of which ſometimes contain 25 gr. of ſulphur. 2 *Gerh. Beytr.* 17. It often forms incruſtations on the brinks of theſe ſprings.

5^thly. *In the form of an alkaline hepar.* This is ſaid to be found in ſome waters in *Ruſſia*. *Schab. Samm.* 4 *Theil.* p. 544. alſo at *Tivoli*.

6^thly. *United to iron and clay* in pyrites.

Laſtly, United to various metallic ſubſtances, as ſhall be ſeen in the next part.

At *Ramelſberg* and the *Hartz* they extract ſulphur from the ſulphureous ores of ſilver, and lead mixed with pyrites, by ſublimation during the torrefaction of thoſe ores: this forms

forms *crude ſulphur*, which is purified by a 2d ſublimation; but in *Bohemia* and *Saxony* they obtain it by immediate diſtillation from the pyrites, and this is again purified by ſublimation in cloſe veſſels. 2 *Schlut.* 222. Moſt of that uſed here comes from *Italy*.

Sulphur is diſcovered in earths or ſtones either by its inflammation, or by diſtillation, with or without white arſenic or mercury, or by ſolution of the matrix in marine, or dilute nitrous acid, or by digeſtion in, or fuſion with fixed alkalis.

PART IV.

Metallic Subſtances.

1. METALLIC ſubſtances are opake bodies, whoſe ſpecific gravity exceeds 5,000, conſiſting of a heavy, dull, brittle earth combinable with phlogiſton, and during that union poſſeſſing a peculiar ſhining appearance. They are all conductors of electricity, and more perfectly ſo than any other bodies during their union with phlogiſton. They are all ſoluble either in the nitrous acid, or in aqua regia, and all precipitable in ſome degree by cauſtic alkalis; and (except platina) by the *Pruſſian* alkali; all when dephlogiſticated communicate a tinge to borax or microcoſmic ſalt when melted with theſe fluxes, or render them opake; all melt in ſome degree of heat, and moſt commonly aſſume a convex ſurface, or if in ſmall quantity a globular form when in fuſion, and in that ſtate are miſcible with each other for the moſt part, but refuſe to unite with any other unmetallic ſubſtance, even their own calces *; but when calcined they are

* Iron is an exception to this rule, for even in its reguline ſtate it is capable of uniting to its own calces ſlightly dephlogiſticated, and to plumbago: ſome of them alſo may contain ſulphur even in their reguline ſtate as nickel, &c.

capable

capable of union with other earths and ſalts. The phlogiſton in all of them is in a pure ſtate, that is, free from water and aerial acid, ſubſtances that invariably accompany it in all other compounds, except acid airs and ſulphur. The more earthy part or calx of ſome metallic ſubſtances has been found to be of an acid nature.

2. There are 17 metallic ſubſtances now known; namely, gold, platina, ſilver, copper, iron, lead, tin, mercury, zinc, regulus of antimony, regulus of arſenic, biſmuth, cobalt, nickel, regulus of mangaueſe, ſyderites, and regulus of molybdena.

Of theſe gold, ſilver, platina and mercury are reckoned perfect or noble metals, becauſe when calcined they recover their phlogiſton without the addition of any phlogiſtic ſubſtance: whereas copper, iron, lead and tin cannot be entirely reduced without ſuch addition, and hence are called ignoble or imperfect: however, all theſe (even mercury when ſolid) are malleable to a great degree, and hence called *intire* metals; whereas zinc, regulus of antimony, regulus of arſenic, &c. are ſcarce at all malleable, and hence are called *ſemi-metals*: however zinc and purified nickel are more malleable than any of the

 reſt.

reſt. Hence there are 4 perfect metals, 4 imperfect, 8 intire, and 9 ſemi-metals.

3. Metallic ſubſtances in their natural ſtate are found either united to their full complement of phlogiſton, and conſequently poſſeſſing their reſpective and peculiar properties, and thence called *native*, or more or leſs deprived of their phlogiſton, and the properties reſulting from their union with it, moſt commonly, if not always, by combination with ſome other ſubſtance, and then they are ſaid to be *mineralized*, becauſe this is their moſt uſual ſtate in the mineral kingdom, and the ſubſtance ſo combined with them is called a *mineralizer*; the whole is called an *ore*; ſo alſo are earths and ſtones, in which metallic ſubſtances are contained in a notable proportion.

4. When the mineralizer is of a *ſaline* nature, and renders the metallic ſubſtance with which it is combined ſoluble in leſs than 20 times its weight of water, the compound is generally ranged among *ſalts*: thus the vitriols of iron, copper and zinc are rather claſſed with ſalts than with ores.

5. The commoneſt mineralizers are ſulphur, arſenic, and fixed air: the leaſt common are the vitriolic and marine acids; the phoſphoric

phoſphoric has been found only in one inſtance; metallic ſubſtances mineralized by fixed air are called *calciform* ores, from their reſemblance to the calces formed by art.

6. It is true that ſome mineralogiſts of the firſt rank exclude arſenic from the number of mineralizers, as it is itſelf a metallic ſubſtance, ſaying, that with equal propriety other metallic ſubſtances that render metals brittle might be called mineralizers; they alſo add, that arſenic is never united to metals but in its reguline ſtate, and therefore that the compound it forms ſhould rather be called an *alloy* than an *ore*; and, indeed, if this laſt circumſtance always took place, I ſhould not heſitate to agree with them; but it ſeems clear to me that the calx of arſenic, and even its acid being capable of uniting with metals, (an union which the calx of no other metallic ſubſtance is capable of contracting) theſe metals cannot unite to that calx or acid without loſing ſome part of their phlogiſton, and conſequently without being mineralized in the uſual ſenſe of that word; yet if regulus of arſenic be combined with metals without any loſs of phlogiſton (an union which art may produce by means of the black flux) I will allow the compound ſhould rather be called an alloy; but ſuch an union I believe ſeldom or ever takes place in the mineral kingdom.

 Hence

Hence I chuſe to follow the common language, which, without very cogent reaſons, ſhould never be departed from.

7. All metallic ſubſtances are therefore of neceſſity ſlightly dephlogiſticated when united to ſulphur; but as metallic calces, in their moſt dephlogiſticated ſtate, are alſo capable of uniting with ſulphur, hence it happens that they are ſometimes more and ſometimes leſs dephlogiſticated in various ſulphurated ores, particularly the pyritous.

8. Metallic ſubſtances mineralized by fixed air are alſo ſometimes more and ſometimes leſs dephlogiſticated.

9. Metallic calces always containing ſome foreign ingredient afford a ſmaller weight when reduced; and it is this laſt that is moſtly denoted, and when the proportion of metal in any ore is aſſigned.

CHAP. I.

Gold.

1. The diſtinctive characters of gold are the following: 1°. A ſpecific gravity reaching to 19,64. 2dly. Inſolubility in all acids, except aqua regia, and the dephlogiſticated marine

marine acid, and precipitability from theſe acids in the form of a purple powder by ſolution of tin, or in a metallic form by the ſolution of vitriol of iron, 3$^{dly.}$ A yellow, or reddiſh yellow colour when in its metallic ſtate.

Gold expoſed to the utmoſt heat of Mr. *Parker*'s lens for ſome hours loſt no ſenſible part of its weight, yet when in contact with earthy matters, it communicated a blue or purpliſh tinge to them, ſo that I believe an exceeding minute portion of it was dephlogiſticated.

Gold Ores.

2. Gold being incapable of uniting with ſulphur, or even with arſenic, but very difficultly and while in fuſion, or with fixed air, is for that reaſon never found mineralized, but either native or inviſibly mixed with other ſubſtances.

Species I.

Native.

3. Native gold is found either *ſeparate* from any matrix in lumps, or viſible grains mixed with ſand, and in this ſtate it is found in many rivers in *France*, *Africa*, and elſewhere, or inviſibly diſperſed through large

maſſes of ſand, particularly the yellowiſh red, or violet, and in this ſtate it is ſo generally diffuſed through all ſpecies of Earths, though in exceeding ſmall quantity, that Mr. *Bergman* thinks it is more univerſally found than any other metal, except iron. 2 *Erde. Beſchr.* 313. If 100 pounds of ſand contain 24 grains of gold, it is ſaid the ſeparation is worth attending to, but in *Africa*, 5 pounds of ſand often contain 63 grains of gold, or even more; the heavieſt ſand, which is often black or red, yields moſt. In *Hungary*, 10,000 pounds of ſand yield but 10 or 12 grains of gold; it was extracted, but with loſs. *Born, letters from Hungary.* Or *viſibly imbodied* in ſome matrix, and in this ſtate it is found, either in a granular, foliated, or ramified form, in ſtones of the calcareous, but chiefly of the ſiliceous genus, as ſpar, gypſum, feltſpar, hornblend, jaſpar, and moſt frequently quartz, in *Hungary*, *Tyrole*, *Siberia*, &c.

4. Gold interſperſed through ſand, is ſeparated by mere mechanical means, as is amply deſcribed in the *Paris Memoirs* 1718, and 1736, and *Borns's Letters from Hungary.*

5. But when it is imbodied in Earths and ſtones, theſe may be eſſayed in the moiſt way by pounding them very fine, weighing a determinate portion, and attempting their ſolution,

lution, if calcareous; in nitrous acid, which will diſſolve the matrix, and leave the gold at bottom untouched, or if gypſeous or ſiliceous by digeſting them in aqua regia, as long as any metallic ſubſtance is taken up, which the ſolution of tin, or phlogiſticated alkali will indicate, and then precipitating the gold by a ſolution of vitriol of iron.

6. Or by Amalgamation, with $\frac{1}{10}$ of their weight of mercury, in a copper or iron veſſel, in which the mercury and pulveriſed ſand are put together with water, which is kept conſtantly boiling, and the mercury after ſome time, abſorbes the gold, from which it is ſeperated by diſtillation, *Lew. Com.* 194.—or by heating the ſand red hot, and quenching it in water 3 or 4 times, then melting it with twice its weight of litharge, then reviving the litharge by charcoal, into lead, which then ſeparates from the ſand, and laſtly, freeing the gold from the lead by cuppellation. *Lewis, Ibid.*

7. Native gold is ſeldom found perfectly pure, being generaly alloyed with ſilver, or copper, or iron, or all three. If ſuch alloy be diſſolved in aqua regia, the ſilver will remain at the bottom in the form of horn ſilver. If then a ſolution of vitriol of iron be dropped into the ſolution of gold, this latter will

be

be precipitated, and the copper and iron may be precipitated by the phlogiſticated alkali, and ſeparated as hereafter will be ſeen.

Species II.

Mixed with yellow or Martial Pyrites.

8. It is found thus mixed in the mine of *Adelfors* in *Sweden*. According to *Cronſted*, § 166, 100 pounds of this ore contains but one ounce of Gold, and it is ſaid to be hardly worth extracting. The pyrites is of a bright yellow colour, cloſe and compact. The gold in this ore is ſaid to be mineralized by ſulphur, by the medium of iron, becauſe it cannot immediately be extracted by aqua regia or amalgamation, but Mr. *Bergman*, though he inclines to the opinion of the mineralization of gold, yet is candid enough to own, that the gold, when extracted from this ore, being of a granular or angular form, it is very doubtful whether it was not rather mixed than truly combined with the ſulphur and iron, and its proportion being exceeding ſmall, it is not wonderful that it ſhould eſcape aqua regia, more eſpecially as the nitrous acid becomes ſo phlogiſticated by acting on the pyrites, as not to be able to dephlogiſticate the marine, and mercury, from the nature of things, can have no acceſs to it.

9. This

9. This and ſuch like ores, may be eſſayed by diſſolving them in about 12 times their weight of dilute nitrous acid, gradually added, and a heat of about 120 degrees; this takes up the ſoluble part, and leaves the gold untouched with the inſoluble matrix, from which it may be ſeparated either by lotion, or by aqua regia, from which it is precipitable as above. The ſulphur floats for the moſt part on the ſolution from which it ſhould be ſeparated by filtration. The ſolution may contain iron, copper, mangancſe, calcareous Earth, or argill; if it be evaporated to dryneſs, and the reſiduum heated to redneſs for half an hour, volatil alkali will extract the copper; the dephlogiſticated nitrous acid, the Earths; the acetous, the mangancſe; and the marine, the calx of iron.

10 Gold may alſo be ſeparated from pyrites after torrefaction, by aqua regia, *Mon. Mineral.* 277.

11. Pyrites containing gold, is alſo found in *Swiſſerland* and *Hungary*, that found in *Hungary*, contains 5 ounces of gold per quintal, *Mon. Expoſitions des Mines*, p. 47. the gold mines of *Norway*, are of the ſame nature as thoſe of *Adelfors*, 2 *Jars*.

12. In

12. In the *dry way*, Mr. *Bergman* eſſays theſe ores, by mixing 2 parts of the ore, well pounded and waſhed, with one and a half of litharge, and 3 of glaſs, covering the whole with common ſalt, and melting it in a ſmith's forge, in a covered crucible; he then opens the crucible, puts a nail into it, covers it, and heats it again, and continues to do ſo until the iron is no longer attacked. The lead is thus precipitated, and contains the gold which is ſeperated by cuppellation, *Scheff.* 239. 1 *Anmerk.*

SPECIES III.

Mixed with Arſenical Pyrites.

13. Found at *Salzbergh* in *Tyrole*, in mountains of quartz and ſhiſtus; the quintal affords only about 25 grains. It is ſeparated by lotion, and affords a profit of between 4 and 500*l*. per an. 2 *Jars*. 78.

SPECIES IV.

Mixed with a white, red, or Vitreous Silver Ore.

14. Near *Cremnitz* and *Schemnitz* in *Hungary*, 2 *Jars*. 165, 195.

SPECIES V.

Mixed with a ſulphurated Ore of Silver, Iron, Lead, and Mangane ſe.

15. Lately found at *Nagaya* in *Tranſylvania*. This ore conſiſts of ſmall dark coloured plates of more or leſs brightneſs, inhering in quartz, and a ſoft whitiſh ſubſtance, which Mr. *Bergman* found to be mangane ſe. Part of the gold may be extracted from it by eliquation in a cuppelling heat, its fuſibility being promoted by the lead.

16. If the dark coloured plates be ſeparated from the remaining maſs, and treated with aqua regia, the gold and iron will be extracted, and may be ſeparated as above mentioned, N° 7. but none can be extracted by amalgamation, *Scopol. An.* 3. p. 90.

17. This ore is ſaid to afford 10 ounces of gold per quintal, beſides ſilver, its ſpecific gravity according to *Gellert*, is 4,043.

SPECIES VI.

Mixed with ſulphurated Iron and Copper, with Mangane ſe.

18. This is a yellow pyrites, found alſo at *Nagaya*, in which gold is contained; Mr. *Bindheim*

Bindheim lately essayed this ore in a particular manner. The pyrites being well pulverised, were heated in an open crucible, until the sulphur was burnt off. The residuum while hot, was thrown into water, a reddish brown matter remained undissolved. This, when dried, was digested in 3 times its weight of aqua regia, then diluted and filtered, and æther poured on it and shaken. The æther took up the gold, and being burnt off, left it in its metallic form, 4 *Berl. Schrift.* 393.

19. In *Peru* gold is found mixed with a stony matter, not well known, and also with a red Earth, from both which it is there extracted by amalgamation, 2 *Jars.*

CHAP. II.

Platina.

1. Platina has as yet been found only among the gold mines of *Peru*. It comes to us in the form of large smooth grains, of an irregular figure, some of them hollow, whiter than iron, intermixed with quartz, and a ferruginous sand, and in the cavities, sometimes particles of gold, but more frequently quicksilver is found, which may be separated by distillation; whence it is conjectured, that it is not brought to us in its natural state, but that it has been separated from gold with other matters,

matters, by amalgamation. Moſt of its particles are friable and magnetic, but ſome few are malleable to a conſiderable degree, and may be ſeparated by a magnet, but according to the accurate experiments of Count *Sickingen*, even theſe contain about $\frac{1}{3}$ of their weight of iron. Before it is ſeparated from quartz, its ſpecific gravity is from 6,000 to 11,000, and after that ſeparation from 16 to 18. It is ſoluble only in aqua regia, or dephlogiſticated marine acid, and is nearly infuſible in terreſtrial fires, the great burning lens of *Paris* only agglutinated its particles in 20 minutes, Mr. *Parker's* perfectly melted them in leſs than two. It is precipitable from its ſolution by ſalammoniac, as our late excellent chymiſt Dr. *Lewis* has diſcovered, a property by which it is eaſily diſtinguiſhed, and ſeparated from all other metals. It is not precipitable by the Pruſſian alkali, as all other metals are.

2. Its ores, if it has any, are not yet known.

3. Platina is purified from iron by reiterated coction in ſpirit of ſalt, ſolution in aqua regia, and precipitation of the iron, by the Pruſſian alkali. When pure, its colour approaches to that of ſilver, its ſpecific gravity is nearly 23,000, it is not in the leaſt magnetic.

CHAP.

CHAP. III.

Silver.

1. Silver is the whiteſt of all metals; its ſpecific gravity when pure is 11,095; it is ſoluble in the concentrated vitriolic acid with the aſſiſtance of heat, and in the moderately dilute nitrous acid without that aſſiſtance; it is precipitable from both by the marine, and from the nitrous in great meaſure by the vitriolic; its calces are reducible without the addition of any phlogiſtic matter, and it is incapable of calcination by mere heat.

Species I.

Native.

2. Native ſilver is found in a granular, lamellar, filamentous, capillary, arboreſcent, or cryſtalized form, inhering either in baroſelenite, lime-ſtone, ſelenite, quartz, chert, flint, ſerpentine, gneiſs, agate, mica, calcareous ſpar, pyrites, ſhiſtus, clay, &c. alſo in ſeparate maſſes of various ſizes, ſome of the weight of 60 pounds, in or near the veins of moſt metallic ſubſtances, particularly in *Peru*, and frequently in various parts of Europe, either of a white, brown, or yellowiſh colour.

3. It is often diffused through sand and ochre, also in grey lime-stone in *Lower Austria*, and in a greenish clay near *Schemnitz*, or mixed with ochre, clay and calciform nickel.

4. It is seldom found pure, being generally alloyed with copper, and sometimes with a small proportion of gold, iron, or regulus of antimony *, and sometimes about 5 per cent. of arsenic †; it is separable from gold and regulus of antimony by solution in nitrous acid, and from copper and iron by precipitating it by the marine acid ‡, and from arsenic by torrefaction.

100 gr. of the horn silver contain 75 of real silver; it is reducible by triturating it with about its own weight of fixed alkali with a little water, then melting the whole in a crucible, whose bottom is covered with mineral alkali well pressed, and covering the mass of horn silver also with the mineral alkali.

5. The native silver found near *Konigsberg* contains so much gold as to acquire a yellow colour from it.

* *Bergm. Sciag.* §, 154. † 13 *Roz. Supplem.* p. 50.
‡ A more perfect manner of separating it from copper will be seen No. 21.

Species II.

Mineralizèd by Sulphur.

Vitreous Silver Ore, Glaſzertz.

6. It is found either in ſolid large lumps, or inhering in quartz, ſpar, gypſum, gneiſs, pyrites, &c. of a lamellar, granular or capillary form, or cryſtalized; it is generally of a lead colour firſt, but grows black by expoſure to the air, but ſometimes grey or black, even when firſt broken; its laminæ are flexible and ductil, and even malleable in ſome degree, and ſo ſoft, that they may be cut with a knife; its ſpecific gravity is 7,200 *; it is one of the richeſt of the ſilver ores.

100 parts of it contain from 72 to 77 of ſilver; it is rarely contaminated with any other metal beſides a ſmall proportion of iron.

7. It is found in *Hungary* near *Shemnitz*, and in *Saxony* near *Freyburgh*, particularly in the famous mine of *Himmelsfurſt*.

8. It is analyſed by boiling it in moderately dilute nitrous acid, uſing about 25 times its weight, until the ſulphur is quite exhauſted.

* *Gellert Anfangs.* 234.

The

The ſilver is precipitated by marine acid, or common ſalt, and eſtimated as in N° 4. The *Pruſſian* alkali will ſhew if any other metal is contained in the ſolution; the gold, if any, will remain undiſſolved; fixed alkalis will precipitate any other earthy matters contained in the ſolution.

9. In the dry way it may be reduced by melting it with the blow-pipe on charcoal; for the ſulphur is diſſipated, and the ſilver remains; or by melting it with $\frac{1}{8}$ of its weight of filings of iron, as the iron will take up the ſulphur and be ſcorified.

SPECIES III.

Mineralized by a ſmall proportion of Arſenic.

10. This ore is of a yellowiſh white colour, and of a ſtriated texture, reſembling biſmuth, but much harder; it melts very eaſily, and if kept in fuſion, it loſes its arſenic, and the ſilver remains almoſt intirely pure, as it contains but very little iron; it contains about 90 per cent. of ſilver, and is found near *Quadanal-Canal* in *Spain*. *Mon. Mineral.* 281.

SPECIES IV.

Mineralized by a large proportion of Arſenic.

11. The proportion of arſenic in this ore is ſo great, that it would ſcarce deſerve to be

called a ſilver ore, if the arſenic were not eaſily diſſipated: the quintal contains but from 4 to 6 ounces of ſilver; it is very ſoft, and eaſily cut, and when cut has a brilliant metallic appearance; it conſiſts of conchoidal laminæ; it is found alſo at *Quadanal-Canal. Mon. Ibid.*

12. It is reduced by evaporating the arſenic, which then leaves the ſilver ſlightly contaminated with iron.

Species V.

Mineralized by Sulphur and Arſenic.

Red Silver Ore, Rothgulden ertz.

13. This is a heavy, ſhining ſubſtance, either tranſparent or opake, moſtly of a crimſon or reddiſh colour, though ſometimes grey or blackiſh, but when ſcraped or powdered always reddiſh; found either in ſhapeleſs maſſes, or cryſtalized in pyramids or polygons, or dendritritical, or plated or radiated incruſtations, on or in matrixes of quartz, flint, ſpar, pyrites, ſparry iron ore, lead ore, pyrites, cobalt ore, jaſper, baroſelenite, gneiſs, &c. when radiated or ſtriated, it is called *rothgulden bluth.* In fire it crackles and melts after it has acquired a red heat, with an arſenical ſmell; it detonnates with nitre; its ſpecific

cific gravity is from 5,4 to 5,684. Mr. *Bergman* found 100 gr. of it to contain 60 of ſilver, 27 of arſenic, and 13 of ſulphur. 2 *Bergm.* 303. but ſometimes it contains even 70 per cent. of ſilver. The darkeſt ores are the richeſt, and theſe often contain a little iron; the yelloweſt are the pooreſt; the moſt yellow does not belong to this ſpecies, being in fact orpiment, containing 6 or 7 per cent. of ſilver.

14. To analyſe this ore in the moiſt way, Mr. *Bergman* adviſes to boil it after it is reduced to a very fine powder in dilute nitrous acids, as in N° 8, and to edulcorate the reſiduum very carefully which contains the ſulphur and arſenic, which may be ſeparated by boiling in a ſufficient quantity of aqua regia: if the ſulphur ſtill retains any luna cornua, it may be ſeparated by cauſtic volatil alkali.

15. In the dry way it is reduced after torrefaction by a mixture of iron and lead; the iron takes up the ſulphur, and the lead the ſilver, which is afterwards ſeparated by cuppellation.

Species VI.

Mineralized by Sulpur, and a very ſmall Portion of Arſenic and Iron.

Black Silver Ore. Schwartz ertz, Schwartz gulden. Silber mulm.

16. This is either of a *ſolid and brittle* conſiſtence, which diſtinguiſhes it from the vitreous ore, and of a glaſſy appearance in its fracture when recent, or of a *looſer texture*, and ſooty or deep black colour, like moſs or thin leaves lying on the ſurface of other ſilver ores, or of thoſe of lead or cobalt, or in clays, ponderous ſpar, gneiſs, &c. it may contain about 25 per cent. of ſilver: the former is found in *Dauphiné*, *Hungary*, and *Saxony*, and contains at moſt 60 per cent of ſilver. *Mon. Mineral.* 302. 3 *Lin. von. Gmel.* 406.

Species VII.

Mineralized by Arſenic, and containing a large Proportion of Iron.

Arſenicomartial Silver Ore, Weiſs ertz, Pyrites Argenteus of Henckel.

17. Mineralogiſts do not well agree about the ore to which this denomination belongs. I follow Mr. *Monnet*, who ſeems to have attended

tended to the diviſion of ores moſt exactly. According to him this ore is a hard ſubſtance, of a white, ſhining appearance, and of a compact, lamellar or fibrous texture; the brighteſt is the pooreſt in ſilver; the richeſt gives only 10 per cent. the pooreſt 6 or 8 ounces: it contains no ſulphur; and hence Mr. *Monnet* calls it a metallic regulus, not conſidering that the iron is in a calcined ſtate, which fully proves that arſenic is a true mineralizer: the iron and arſenic are in various proportions, but the arſenic always exceeds.

It is found in *Saxony*, the *Hartz*, at *Quadanal-Canal*, &c.

18. It is eſſayed in the moiſt way, as in Nº. 4.

Species VIII.

Mineralized by Arſenic and Sulphur, with a ſmall Proportion of Copper, and a ſtill ſmaller of Iron.

White Silver Ore, Weiſsgulden.

19. It is a heavy, ſoft, opake ſubſtance, fine grained or ſcaly, bright and ſhining in its fractures, of a whitiſh, ſteely or lead colour, ſometimes cryſtalized in pyramidical or cylindrical forms, but often in amorphous grains, or reſembling moſs, or in the form of

thin laminæ incrustating other bodies, found in quartz, spar, stellstein, pyrites, blend, lead ore, cobalt ore, sparry iron ore, fluors, &c. It is very fusible; its specific gravity 5,000 or 5,300; its proportion of silver from 10 to 30 per cent.

20. It is found, though not commonly, in *Saxony*, *Hungary*, the *Hartz*, and *St. Marie aux Mines*.

21. Mr. *Bergman* analyses this ore in the following manner. Having pulverized and weighed a certain portion of it, he attempts its solution in about 12 times its weight of dilute nitrous acid: the copper and silver are dissolved, and a white residuum remains. The silver he precipitates, not with marine acid, for this would unite also to the copper, and with the silver form a triple salt, which would also fall, but with a clean plate of copper previously weighed; the silver being in its metallic form, may immediately be weighed, and its contents known: the copper should then be precipitated by aerated mineral alkali; 194 gr. of this precipitate well dried are equivalent to 100 of copper in its metallic form; but from this last, the weight, which the plate of copper lost, must be subtracted.

22. The

22. The white residuum, containing the sulphur, arsenic and iron, is next to be examined: by boiling it in spirit of salt, the arsenic and iron are taken up; the arsenic is to be precipitated by the addition of water, and then the iron by the *Prussian* alkali; the sulphur remains undissolved, and may be treated with volatil alkali to try whether it retains any copper or horn silver. 2 *Bergm.* 418.

SPECIES IX.

Mineralized by Arsenic and Sulphur, with a large Proportion of Copper and some Iron.

Grey Silver Ore, Fahl erz.

23. This is a hard, grey, or dark grey substance, more or less brilliant, sometimes crystalized, but mostly amorphous, and is, in fact, the grey copper ore hereafter to be mentioned, Chap. 4. N°. 26, impregnated with silver, and varies much in its contents from about 1 to 12 per cent. of silver, and from 12 to 24 of copper, the remainder being sulphur and arsenic, with a little iron: the richer it is in copper, the poorer in silver, and reciprocally. Mr. *Monnet* remarks, that wherever copper is united to arsenic, silver is also found; it is the commonest of all the silver ores: the grey silver ore of *Dal* in

Sweden contains alſo regulus of antimony, and, according to Mr. *Bergman*, it contains 24 per cent. of copper, and 5 of ſilver; but this belongs to the next Species.

SPECIES X.

Mineralized by Arſenic and Sulphur, with Copper, Iron, and Regulus of Antimony.

Brown Silver Ore, Leber erz.

24. Its colour is moſtly of a reddiſh brown, ſometimes dark grey, ſometimes it is found cryſtalized in pyramids, but moſtly amorphous; when ſcraped it appears red; it contains from 1 to 5 per cent. of ſilver; the greateſt part is copper, and the next in proportion is arſenic.

It is found in *Sweden*, *Germany* and *Spain*.

25. It is analyſed by boiling it in about 6 times its weight of dilute nitrous acid, which will take up the ſilver and copper, and leave the regulus of antimony and arſenic: theſe being boiled in ſtrong nitrous acid are dephlogiſticated, and the arſenic becomes ſoluble in water; the calx of antimony remains undiſſolved; the ſulphur may be found in a ſecond experiment, uſing aqua regia inſtead of

of the concentrated nitrous acid; the ſilver and copper are ſeparated as in N°. 21.

SPECIES XI.

Mineralized by Sulphur and Arſenic, with Iron and Regulus of Antimony.

Plumoſe Silver Ore, Feder ertz.

26. In point of colour this ore varies from a dull white to grey, dark blue, brown or black; it is found in a capillary form, or, like wool, ſometimes looſe, at other times attached, its filaments are rigid and inflexible; the whiter it is, the richer; but it ſeldom contains even 1 per cent. of ſilver. It is found in *Saxony* and elſewhere. Some confound it with the foregoing.

Its analyſis may be underſtood from N°. 21 and 25.

SPECIES XII.

Mineralized by Sulphur and Arſenic, with Cobalt and Iron.

Cobaltic Silver Ore.

27. This ore is diſtinguiſhed by roſe-coloured particles, of cobalt diſperſed through a dark brown, blackiſh, or grey, and ſomewhat ſhining ſolid maſs. It is found in *Saxony*,

Saxony, and at *Allemont* in *Dauphiné*, and contains about 40 or 50 per cent. of ſilver, and very little cobalt; the arſenic is in an acid ſtate, and united to the cobalt.

28. To analyſe it, let it be diſſolved in nitrous acid; the ſilver and cobalt will be taken up, and moſt of the iron will remain calcined, together with the arſenic; the ſilver may be precipitated by the marine acid, and the cobalt by an aerated fixed alkali, and its weight determined, as will be ſhewn in Chap. 13.

Species XIII.

Mineralized by Sulphur, with Regulus of Antimony and Barytes.

Butter-milk Ore.

29. It appears in the form of thin pellicles, on granular ſpar.

Species XIV.

Combuſtile Silver Ore.

30. This is black and brittle, and leaves about 6 per cent of ſilver in its aſhes, it is a coal in which ſilver is found. The ſilver is extracted as uſual by nitrous acid.

Species XV.

SPECIES XV.

Mineralized by the Vitriolic and Marine Acids, with a little Iron, and ſometimes with a mixture of the Vitreous Ore.

Corneous Silver Ore, Horn ertz.

31. This ſcarce and valuable ore is of a white, grey, pearly, or yellow, green, brown, purple, or black colour, frequently cryſtalized in a cubic form, ſometimes reſembling an Earth, eaſily fuſible without any ſmoke. The black ſort is friable, and eaſily pulveriſed, but the other ſort is in ſome degree malleable, may be cut with a knife, and takes a ſort of poliſh when rubbed. The vitreous ore mixed with the black, is ſoluble in nitrous acid, and may by that means be ſeparated, the ſaline ores being inſoluble in that acid; if pure from iron, theſe ores ſhould contain 70 per cent of ſilver at leaſt, but they moſtly contain ſome portion of iron, of which ſome is even united to the marine acid according to *Monnet*. It is found in *Saxony*, *Bohemia*, *St. Marie aux Mines*, *Siberia*, and *Peru*. It was firſt eſſayed by Mr. *Wolfe*, *Phil. Trans.* 1776, and afterwards, though leſs exactly, by Mr. *Monnet*, in 1777, ſee 9 *Mem. Etr.* p. 717.

32. Mr.

32. Mr. *Bergman* gives the following moſt ingenious method of analyſing theſe ores in the moiſt way.

1°. He digeſts this compound ore in the marine acid for 24 hours, by which means the vitriol of ſilver is decompoſed, and the whole is converted into horn ſilver. He then judges of the quantity of the vitriol of ſilver, by the quantity of vitriolic acid let looſe in the liquor, and to find how much this is, he decants the clear liquor, and drops into it a ſolution of nitrous barcſelenite, which is immediately decompoſed by the vitriolic acid, and forms true vitriolic baroſelenite, of which 100 grains contain 15 of dephlegmated vitriolic acid, and ſo in proportion. Now 100 grains of vitriol of ſilver, contain 25,37 of the ſame dephlegmated acid, ſo that 25,37 grains of this acid, indicate 100 of vitriol of ſilver, and ſo in proportion, and thus the quantity of ſilver in the vitriol of ſilver is alſo found, as 100 grains of it contain 74,62 of ſilver,* and the proportion of vitrol of ſilver being known, that of horn ſilver of courſe, is known; but if the ore be of the black kind, after the whole is turned into horn ſilver, it ſhould be digeſted in cauſtic volatil

* According to Mr. *Bergman*, 100 parts of vitriol of ſilver, contain but 68,75 of ſilver.

alkali,

alkali, which will take up the horn ſilver, and leave the vitreous ore. The iron, if any, ſhould be precipitated from the firſt ſolution, by the *Pruſſian* alkali, after the precipitation of the baroſelenite.

Uncertain Mineralizations.

Species XVI.

Gooſe-dung Ore.

33. This is of a greeniſh colour, mixed with yellow and red; it is ſaid to contain about 6 per cent of ſilver. Some think it a mixture of red ſilver ore, and calx of nickel.

Species XVII.

Foliaceous Silver Ore. Silberartiges, Bergzunder, Blatter erz.

34. Its colour is *mortdoré*. It is thought by ſome to be native ſilver, by others a mixture of galena, ochre, and ſilver, it is found in mountain cork, it is ſo light, that it ſwims on water. It contains but one ounce of ſilver per quintal. See *Lehman's Experiments, Mem. Berl.* 1758.

Species XVIII.

Mineralized by Sulphur, Arſenic and Biſmuth.

35. Such ores have been talked of, but their exiſtence has not as yet been proved.

36. Silver has alſo been found in the ſulphurated ore of zinc called pech blend, and in that of lead called galena, particularly the latter; alſo in the copper pyrites, but in ſmall quantity, as ſhall be mentioned in their proper places.

37. If an ore yields ½ per cent of ſilver, it is generally worth extracting.

CHAP. IV.

Copper.

1. Its colour is pale red as is well known. Its ſpecific gravity from 8,7 to 9,300, depending not only on its purity, but alſo on its condenſation, by hammering. It is ſoluble not only in acids, but alſo in alkalis and neutral ſalts. It is precipitable from moſt acids, in its metallic form, by a clean plate of iron, and moſt of its acid ſolutions are convertible into a deep blue, by volatil alkalis. Theſe characters are ſufficient to diſtinguiſh it.

Species I.

Native.

2. Native copper, that is copper in a more or leſs malleable ſtate, and either of its own peculiar, or of a grey or blackiſh colour, has been found either in grains, or in large ſhapeleſs ſolid lumps, or in a foliated, capillary, arboreſcent form, or cryſtalized in quadrangular pyramids, in or on clay, ſhiſtus, quartz, fluors, zeolytes, &c. in *Siberia*, *Sweden*, *Germany*, *Hungary*, *Tranſylvania*, &c.

3. It undoubtedly has ſometimes been produced from precipitation by iron from waters in which it was held in ſolution, and this is the pureſt ſort, but in many caſes it could not have been produced in that manner, and then this ſort is never very pure, but mixed either with gold, ſilver, or iron, or with ſulphur; this laſt combination forms what is called *black copper*.

4. All theſe impurities are diſcoverable by ſolution, in nitrous acid; the gold remains undiſſolved in the form of a black powder, ſoluble in aqua regia; the ſilver may be precipitated by the marine acid, or ſtill better by a clean poliſhed plate of copper, the iron is

ſeparated by boiling the whole as it is dephlogiſticated, and rendered thereby inſoluble.

Mineralized.

5. We may obſerve in general, that all copper ores after roaſting, communicate a blue colour to volatil alkali, on digeſting them in it. Before roaſting, it is poſſible that arſenic may prevent that effect, or even ſulphur, if in ſufficient quantity.

SPECIES II.

Mineralized by the Aerial Acid.

Calciform Ores.

6. Of theſe there are three varieties, the red, the green, and the blue, all are ſoluble in acids, and blacken in a moderate heat.

I. VARIETY.

Red, Minera cupri calciformis Rubra, Minera hepatica, Lebererts.

7. We ſometimes meet with this ore in a looſe form, then called copper ochre, but generally it is moderately hard, yet brittle, ſometimes cryſtalized and tranſparent, either in a capillary form, or in cubes, priſms, or pyramids,

pyramids: it is found in *England*, *Scotland*, *Germany*, &c. it effervefces with acids.

8. According to Mr. *Fontana*, 11 *Roz.* 511. 100 parts of it contain 73 of copper, 26 of fixed air, and 1 of water. Mr. *Bergman* alfo found it to contain fixed air, 2 *Bergm.* 430. The brown, or hepatic ore, contains a variable proportion of iron or pyrites, and fometimes fulphurated copper, and hence affords from 20 to 50 per cent. of copper. It is often iridefcent.

II. Variety.

Green, Malachite, Mountain Green.

9. *Malachite* has the appearance of green jafper, but is not quite fo hard, for it does not ftrike fire with fteel; it is either of a radiated or equable texture, generally of an oval form, and the fize of an egg, but fometimes it forms capillary filaments. Its fpecific gravity, according to *Mufchenbroeck*, is from 3,5 to 3,994; it is fometimes mixed with calcareous Earth and gypfum. It is found in *Norway*, *Siberia*, &c.

10. According to Mr. *Fontana*, 100 Parts of the pureft fort, contain 75 of copper, and 25 of aerial acid and water.

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11. *Mountain Green*, is generally found in a looſe and friable ſtate, rarely cryſtalized and indurated, often mixed with calcareous Earth and iron, and ſome arſenic. 100 Parts of the pureſt contain 72 of copper, 22 of aerial acid, and 6 of water.

III. VARIETY.

Mountain Blue, Chryſocolla of ſome.

12. This alſo moſt frequently appears in a looſe form, but ſometimes indurated and even cryſtalized, but it is then mixed with quartz. 100 parts of it contain about 69 of copper, 29 of aerial acid, and 2 of water. Mr. *Morveau*, in the *Memoirs of Dijon*, for 1782, has ſhewn, that the calces of copper are determined rather to a blue than a green colour, by a greater proportion of phlogiſton.

13. They are analyſed in the moiſt way by ſolution in acids, and precipitation by the mineral aerated alkali, if they be pure, or by the *Pruſſian* alkali, if they contain earths. 194 grains of the precipitate formed by the mineral alkali are equivalent to 100 of copper in its metallic ſtate: ſo alſo are 350 gr. of the precipitate formed by the *Pruſſian* alkali, as Mr. *Bergman* has determined: copper alſo may be precipitated in its metallic

ſtate

ſtate by means of iron, though it is not eaſy to get it pure, if the nitrous acid be the ſolvent.

14. I have found that 112 gr. of good iron, precipitate 100 of copper from a ſaturate and dilute ſolution of it in the nitrous acid, and 80 gr. of the ſame iron precipitate, 100 of copper from a ſaturate and dilute ſolution of it in the vitriolic acid; ſo that weighing the iron before and after, the quantity of copper may be eſtimated by the loſs of weight of the iron; but care muſt be taken that the iron do not remain in the nitrous acid after the copper is precipitated. Experience will point out ſome other precautions too tedious to be inſerted here.

15. If iron be mixed with the ore, it may be ſeparated by long boiling in nitrous acid.

16. In the dry way, after torrefaction, they may be eſſayed by melting them with $\frac{1}{2}$ or $\frac{3}{4}$ of their weight of borax, and $\frac{1}{4}$ of their weight of pitch. Some loſs always attends the black flux. Thus Mr. *Fontana* having eſſayed 576 gr. of a calciform ore by black flux, obtained but 376 or 380 of copper, yet by diſtillation he got 408. 11 *Roz.* p. 511.

SPECIES III.

Cupreous Stones.

Analogous to the calciform ores are the cupreous ſtones, *Turquoiſe* and *Lapis Armenus.*

17. *Turquoiſe* is the tooth of an animal penetrated with the blue calx of copper; it loſes its colour when heated; it is opake, and of a lamellar texture, and ſuſceptible of a fine poliſh; its ſpecific gravity is from 2,5 to 2,908; ſome are of a deep blue, ſome of a whitiſh blue, but become of a deeper when heated. This ſtone is found in *Perſia* and *Languedoc.* The copper may be extracted from it by diſtilled vinegar. According to *Reaumur*, *Mem. Par.* 1715, nitrous acid will not diſſolve that of *Perſia*, though it will that of *France*, which ſhews a difference between them.

18. *Lapis Armenus* is another blue ſtone which does not admit of any poliſh, and conſiſts of calcareous earth, or gypſum penetrated with the blue calx of copper: hence it ſometimes efferveſces with acids, and ſometimes not, but never gives fire with ſteel; it loſes its colour when heated.

Species IV.

Mineralized by Sulphur with ſcarce any Iron.

Vitreous Copper Ore, Kupfer glaſs ertz.

19. Its colour is red, brown, blue or violet; it is generally ſo ſoft as to be cut with a knife, and as to form, it is ſometimes cryſtalized in regular figures, and ſometimes amorphous; it is much more fuſible than pure copper; its ſpecific gravity is from 4,81 to 5,338. It is found in the mines of other copper ores, and in lime-ſtone, ſpar, quartz, mica and clay; it is the richeſt of all the copper ores, and affords from 80 to 90 per cent. of copper, 10 or 12 of ſulphur, with a ſmall proportion of iron; the red ores are the pooreſt, containing moſt iron.

20. To analyſe this ore, Mr. *Bergman* adviſes a ſolution of it in 5 times its weight of concentrated vitriolic acid by ebullition to dryneſs and the ſubſequent addition of as much water as will diſſolve the vitriol thus formed. This ſolution he precipitates by a clean bar of iron, and thus obtains the copper in its metallic form. If the ſolution be contaminated with iron, he re-diſſolves thus the copper thus obtained, in the ſame manner, and ſo procures a richer ſolution, which he again precipitates with iron.

21. Dr. *Fordyce*, in the *Philosophical Transactions* for 1780, suggests an improvement, by first dissolving the ore in nitrous acid, and precipitating it by a fixed alkali (if this solution be boiled, any iron it may contain will be precipitated) the precipitate he re-dissolves in vitriolic acid, and precipitates it with iron.

22. The proportion of sulphur may be found by dissolving the ore in dilute aqua regia, as the sulphur will remain undissolved.

Species V.

Mineralized by Sulphur, with 20 *or* 30 *per cent. of iron.*

Azure Copper Ore, Kupfer Lazur, Kupfer malm.

23. This differs from the foregoing only in containing more iron; its colour consists in various shades of blue, or reddish blue; it is as hard, and much more brittle; it contains from 40 to 60 per cent. of copper, from 20 to 30 of iron, and the remainder sulphur; the poorer it is in iron, the richer in copper; it has been by many confounded with indurated *mountain blue*.

Species VI.

Mineralized by Sulphur; with a large Proportion of Iron.

Yellow Copper Ore, yellow Pyrites.

24. Its colour is yellow, or yellow mixed with red or green, or variegated like a pigeon's neck; it is moderately hard, not readily giving fire with ſteel as other pyrites do; in its fracture it preſents ſharp fragments; it is ſometimes found cryſtalized, and ſometimes amorphous; its ſpecific gravity is about 4,16; it occurs both in ſeparate maſſes and imbodied in ſtones, and is the commoneſt of all the copper ores.

25. With reſpect to its contents, the cryſtalized ſort is the pooreſt in copper, of which it contains only from 4 to 8 per ccnt, the remainder is chiefly iron; it is generally reddiſh, and is in fact a martial pyrites, with a ſmall proportion of copper; the greeniſh yellow contains moſt ſulphur, and from 15 to 20 per cent. of copper; the pure yellow contains moſt copper; namely, from 20 to 30 per cent. its texture is foliated; theſe pyritous ores always contain argill, and a little of ſiliceous earth.

Species VII.

Mineralized by Sulphur and Arſenic, with a little Iron.

Arſenical or grey Copper Ore. Kupfer fahl ertz, Weiſs kupfer ertz.

26. This is of a white, grey, or brown colour; it is moderately hard, and very brittle, ſometimes cryſtalized, and often of an indeterminate figure; it is of very difficult fuſion, and heavier than the preceding.

27. It contains from 35 to 60 per cent. of copper; the brown is the richeſt in copper; the white or grey contains moſt arſenic; it frequently contains ſilver, and if this exceeds 1 or 2 per cent. it is called *grey ſilver Ore.*

It is found imbodied in all ſorts of ſtones, and mixed with other copper ores as well as with the ores of other metals.

28. The analyſis of theſe ores in the moiſt way may be underſtood from what has been already ſaid. To eſſay them in the dry way, they ſhould firſt be pulverized and ſeparated as much as poſſible from ſtony and earthy particles, then roaſted to ſeparate the ſulphur and arſenic, then melted with a mixture of an equal weight of Mr. *Tillet*'s flux, which conſiſts

consists of 2 parts pounded glass, 1 of calcined borax, and $\frac{1}{8}$ of charcoal: if the ore be poor more borax may be added; black flux is hurtful, as it forms an hepar which holds part of the copper in solution. *Mem. Par.* 1775.

29. Mr. *Margraaf*, in the Memoirs of *Berlin* for 1775, recommends a mixture of equal parts of clay well washed, fluor, and lime-stone, and $\frac{1}{2}$ part of charcoal, with an equal weight of the torrefied ore; the whole to be melted in a porcelain heat. The coal he uses is that left after the distillation of tartar.

Species VIII.

Mineralized by Sulphur and Arsenic, with Zinc and Iron.

Blendose Copper Ore.

30. Mr. *Monnet* says he has met with this ore only at *Catharineberg* in *Bohemia*: it is of a brown colour, of a hard, solid, and compact granular texture; it contains from 18 to 30 per cent. of copper.

31. It is analysed in the liquid way by solution in nitrous acid and precipitation of the copper by iron: the iron and zinc are precipitated

pitated then by the *Pruſſian* alkali; the precipitate calcined is re-diſſolved in nitrous acid, and the ſolution evaporated to dryneſs; the iron being thus deplogiſticated becomes inſoluble in nitrous acid; the calx of zinc is rediſſolved in that acid, and again precipitated by the *Pruſſian* alkali. 100 gr. of that precipitate waſhed and dried are equivalent to 20 of zinc in its metallic ſtate, and 100 gr. of dephlogiſticated iron are equivalent to 73,5 of iron in its metallic ſtate.

SPECIES IX.

Argillaceous, Shiſtoſe, or ſlaty Copper Ore, Kupfer Schiefer.

32. This ore ſeems to conſiſt of the vitreous copper ore, intimately combined with ſhiſtus, and not barely diſperſed through it in viſible particles; it is of a brown or black colour, lamellar texture, and very heavy; it affords from 6 to 10 per cent. of copper, and is of difficult fuſion, unleſs lime-ſtone be added; it contains a little bitumen, calcareous earth and iron, as *ſhiſti* do.

SPECIES X.

Bituminous Copper Ore. Kupfer brand ertz.

33. This is ſaid to be found in *Sweden*; it is a ſpecies of coal which gives little or no flame,

flame, but consumes and leaves ashes, from which copper is extracted.

Species XI.

Copper in a foreign Form.

34. Animal and vegetable substances are sometimes found penetrated with copper.

Species XII.

Mineralized by the Vitriolic or Marine Acids.

35. These are mentioned and described in the second part: in the dry way they are reducible by Mr. *Tillet's* flux.

CHAP. V.

Iron.

1. Its specific gravity is from 7,6 to 8,00, that of the most dephlogisticated calx of iron, only 6,7. It is soluble in all acids, and the saturate solution precipitable by vegetable astringents of a *black* colour, and by *Prussian* alkali of a *blue*; in its metallic or slightly dephlogisticated state it is attractable by the magnet; it is the most difficultly fusible of all metallic substances, except platina and manganese.

Species I.

Native.

2. It is now known that native iron exists in many places, the moſt remarkable maſs of this ſort is, that diſcovered in *Siberia*, which weighs 1600 pounds. It is of that ſpecies called *redſhort* iron, being malleable while cold, but brittle when red hot. *Pallas Reiſen*, 3 *Theil*. p. 411.

Mineralized.

Calciform Ores.

3. The baſis of the calciform ores, is either the black or blackiſh brown calx of iron, which is in ſome meaſure phlogiſticated and magnetic, or the red calx of iron, which is more dephlogiſticated, and not magnetic before torrefaction.

Species II.

Brown Calx of Iron, mixed with Iron in its metallic State.

Steel Ore. Stahlerz. Ferrum Chalybeatum, Lin. Minera Ferri nigra. Cronſt. §. 212.

4. Of a dark ſteel colour, ſolid, compact, and ſhining in its fracture; ſcarcely gives fire with

with ſteel, gives a black powder, is magnetic, and in ſome degree malleable when red hot. It affords from 60 to 80 per cent. of good iron. It is found at *Adelfors* and *Dannemora* in *Sweden*, alſo in the *Iſle of Elbe*, and *North America.*

5. Chryſtalized iron ore in an octohœdral or cubic form, *ferrum teſſulare*, and *minera ferri cryſtalizata* of *Wallerius*, belongs to this ſpecies, it is ſomewhat leſs magnetic, probably becauſe it contains leſs of metallized iron.

Species III.

Magnet.

6. This differs but little in its appearance from the preceding ore, but has leſs luſtre; it is either coarſe or fine grained, the coarſe grained loſes its power ſooneſt. It ſeems to contain a ſmall quantity of ſulphur, as it ſmells of it when red hot. It is probable that it contains more particles of iron in its metallic form, than the preceding ore, but it is often contaminated with a mixture of quartz and argill. It is poſſible it may contain nickel, for this when purified to a certain degree, acquires the properties of a magnet, 2 *Bergm.* 242. Its conſtitution has not as yet been properly examined.

Species IV.

Brown Calx of Iron, combined with Plumbago.

Black Eiſen Glimmer, Schwartz Eiſen Rahm or Eiſenman.

7. This conſiſts of black ſhining ſcales, more or leſs magnetic; Mr. *Rinman* found it to conſiſt of plumbago, and 26 per cent. of iron. *Hiſtoria Ferri.* §. 57.

Species V.

Brown Calx of Iron, united with the white Calx of Manganeſe, and mild Calcareous Earth in various proportions.

White or Sparry Iron Ore, Weiſs Eiſen Spath, Stahlſtein.

8. Its colour when freſh dug is whitiſh, but by expoſure to the air, it firſt becomes grey, then brown, at laſt reddiſh, yellowiſh, or black. Its ſhape, either amorphous or rhomboidal, it is frequently tranſparent, its texture lamellar, ſcaly, granular, or cellular. Sometimes it aſſumes a ſtalactitical form, and ſometimes it is found in a powdery ſtate, and is then of a brown blackiſh colour, is frequently interſperſed with quartz and pyrites;

rites,&c.and does not give fire with ſteel, unleſs theſe foreign ſubſtances be ſtruck. Its ſpecific gravity is from 3,6 to 3,895, or 4,000 it feebly effervеſces with acids, particularly when pounded and heated, affords from 20 to 27 per cent of fixed air. It is ſcarce ever magnetic before calcination, but if heated, it decrepitates, grows black, becomes magnetic, and loſes from 15 to 40 per cent of its weight.

9. 100 Parts of this ore from *Eiſenärtz* in *Steria*, afford according to Mr. *Bergman*, 38 of the brown calx of iron, 24 of the white calx of manganeſe, and 38 of mild calcareous Earth. Another ſort from *Weſt Silvretberg* contains 22 of the brown calx of iron, 28 of the white calx of manganeſe, and 50 of mild calcareous Earth. What quantity of iron and manganeſe in a reguline ſtate, theſe quantities of each calx would produce, may be ſeen by the table inſerted at the end of this treatiſe; the aerial acid is united not only to the Earth, but alſo to the metallic calces, as appears by its proportion. Many other ores are poorer, and ſome to ſuch a degree as not to deſerve the name of an ore. It is frequently mixed not only with quartz and pyrites, as already mentioned, but alſo with ſhoerl, zeolyte, mica or aſbeſtos.

10. When this ore bears a ſtalactitical appearance, and is very white, it is called *flos ferri* and *eiſen bluth*: this affords 27 per cent. of reguline iron according to Mr. *Rinman*, and conſequently 35 of the brown calx.

SPECIES VI.

Magnetic Sand.

11. That of *Virginia*, whoſe colour is black, is of this ſort; its ſpecific gravity is 4,600, and it contains about ½ its weight of iron; but its compoſition has not yet been diſcovered.

SPECIES VII.

Red Calx of Iron indurated, and combined with a little Argill, and frequently with Mangane∫e.

Hæmatites. Glaſs kopf.

12. It is generally of a red, yellow, purple, or brown colour, of a metallic luſtre, and very hard, though ſeldom ſo hard as to give fire with ſteel; when ſcratched, it ſhews a red trace; it is not magnetic before torrefaction, but by that heat it becomes black and magnetic; its ſtructure is either ſolid, granular, ſcaly, or fibrous; it occurs either in ſhapeleſs

ſhapeleſs maſſes, or in a ſtalactitical form, or even cryſtalized in regular forms according to *Gmelin*, though Mr. *Deliſle* denies it: in ſome places it forms whole mountains; it affords from 40 to 80 per cent. of iron. According to Mr. *Gerhard* it contains argill, for he extracted alum from it. Mr. *Hielm* found it alſo to contain manganeſe.

Species VIII.

Hæmatites in a looſe form, mixed with a notable Proportion of Argill.

Hæmatitical yellow, red and brown Ochres.

13. Ochres are diſtinguiſhed from clays by containing a larger proportion of martial particles; thoſe that become brown by calcination, and alſo magnetic, belong to this ſpecies; ſometimes the ferruginous particles are mixed with argill, and calcareous or muriatic earths, and then theſe ochres effervesce with acids.

Species IX.

Red Calx of Iron combined with Plumbago.

Red Eiſen Glimmer, Eiſenrahm and Eiſenman.

14. This differs from the black in this, that it is not magnetic before torrefaction.

SPECIES X.

Red Calx of Iron, mixed with a ſmall Proportion of the brown, and indurated.

Torſten.

15. This is of a bright bluiſh black, or yellowiſh grey colour, and fibrous texture, ſhews a red trace when ſcratched, and is weakly magnetic before calcination. According to Mr. *Rinman* it is leſs dephlogiſticated than hæmatites. *Hiſtoria Ferri*, §. 285.

SPECIES XI.

Emery.

16. Emery ſeems to be a mixture of the red and white calces of iron, with ſome unknown ſtony ſubſtance, perhaps tripoli; it ſcarcely yields in hardneſs to any ſubſtance, except diamond; the beſt ſort is of a dark grey colour, but becomes brown, and in great meaſure magnetic by calcination; other ſorts are of a reddiſh ruſty white, or yellowiſh colour; its ſpecific gravity is from 3,000 to 4,000; it is never uſed as an iron ore, nor is its proportion of iron well known.

SPECIES

SPECIES XII.

Red Calx of Iron united to Siderite.

Grey Iron Ore.

17. This has a ſhining metallic appearance, and commonly gives fire with ſteel; it is not in the leaſt magnetic, and when ſcratched ſhews a red trace; it yields from 40 to 66 per cent. of *coldſhort* iron.

18. The ore called by the *Swedes ſiu ſtierne malm*, or *minera pleiadum*, is a mixture of the grey iron ore, with rhombic nodules of that deſcribed in N°. 5.

SPECIES XIII.

Argillaceous Iron Ores.

19. Of theſe we may diſtinguiſh two principal varieties, namely, thoſe found in mountains and high lands, and thoſe found in ſwampy grounds, or low lands overflown with water; both are deſtitute of metallic luſtre, but very weighty, and ſome of them when dry abſorb water like clays.

I. Variety.

High land Argillaceous Ores.

Minera ferri Ochracea.

20. Theſe are either yellow, red, brown, or greyiſh, indurated and friable, or looſe and powdery, or in grains; they conſiſt chiefly of the red or yellow calx of iron, or of the grey iron ore, or *torſten* in a looſe form, mixed with argill or clay, and conſequently often contain mangaueſe, or ſiderite, and ſome, particularly in *France*, and the neighbourhood of *Liege*, are ſaid to contain the calx of zinc. Hence there are many varities of them, and their yield of iron, as well as its qualities, are very different: they do not effervеſce with acids, (unleſs calcareous or muriatic earth be caſually mixed with them,) and are difficultly ſoluble in them; the moſt ſoluble are the beſt; they never obey the magnet before calcination, and rarely after it.

21. Horn-ſtone over-loaded with iron belongs to this ſpecies.

22. Mr. *Rinman* mentions a *white* iron ore found in *Kent*, mixed with clay or marl, which affords 47 per cent. of brittle iron, and

and is ſcarcely ſoluble in acids. *Hiſtor. ferri,* p. 733.

II. Variety.

Swampey Argillaceous Ores.

Minera ferri Lacuſtris vel ſubaquoſa. Mine de fer Limoneuse.

23. When dry, this ore is friable, and brown, or browniſh black, and appears either in lumps of an irregular ſhape, or in round balls porous or ſolid, or in flat round pieces, or in grains, and ſometimes in ſlender triangular priſms parallel to each other, and very brittle. It is mixed with argill and extractive matter, and becomes magnetic after calcination, by which operation it loſes about $\frac{1}{4}$ of its weight, and the greater part of what is thus volatilized is water, the remainder aerial acid and volatil alkali. The crude ore affords about 36 per cent. of regulus, and after calcination about 50 per cent. it is the chief matrix of ſiderite, and the iron procured from it is *coldſhort*, at leaſt in *Sweden.* The iron of *Huſaby*, of which Mr. *Bergman* treats in his analyſis of iron, is drawn from this ore. Mr. *Hielm* has found ſome ſorts of it to contain 28 per cent. of manganeſe.

SPECIES XIV.

Red Calcareous Iron Ore.

24. This is found in a looſe form in many parts of *England*; it effervefces ſtrongly with acids, and is uſed as a pigment.

SPECIES XV.

Siliceous Iron Ore.

25. Beſides jaſper, garnet and trapp overloaded with iron, there is found, principally in *France*, a black, heavy, unmagnetic ſand, of the ſiliceous kind, which is ſaid to contain iron and zinc in great quantity.

26. Baron *Born*, in his letters from *Hungary*, mentions a blue cryſtalized iron ore, which he ſays is a ſhoerl overloaded with iron.

SPECIES XVI.

Muriatic Iron Ore.

27. Serpentine overloaded with iron forms this ſpecies, but it is ſeldom worked.

SPECIES XVII.

Martial Calamine.

28. Calamine is properly an ore of zinc, but ſometimes it contains ſo large a proportion

tion of iron as to be worked with a view of obtaining this metal; it conſiſts of a mixture of quartz and argill, with the calces of iron and zinc; its colour is yellow, red, or brown, and it is moderately hard.

SPECIES XVIII.

Mineralized by Sulphur.

Martial Pyrites.

29. Theſe are ſtony concretions of ſulphur, clay, and calx of iron, ſo hard as to give fire with ſteel. There are two principal varieties of them.

I. VARIETY.

Pale yellow Pyrites.

30. This has been already deſcribed among the ores of alum.

II. VARIETY.

Brown or reddiſh brown Pyrites. Minera ferri hepatica, Waſſer kieſs.

31. It is generally of a ſpherical ſhape, or cryſtalized in cubic, rhomboidal, or other polyhædral forms, and is devoid of metallic luſtre; it difficultly gives fire with ſteel, and contains very little ſulphur, but much more iron

iron than the yellow pyrites, and not unfrequently a mixture of calcareous Earth. It is ſometimes magnetic, before, and always after calcination. It is incapable of vitriolization. The iron it affords is brittle.

Species XIX.

Mineralized by Sulphur and Arſenic.

White, Grey, or Bluiſh grey Pyrites, Marcaſſite Rauſh gelb kieſs, Gift kieſs, Arſenic Stein.

32. It is found either in ſolid compact maſſes of a moderate ſize, or in grains, it gives fire with ſteel; when burnt, it affords a blue flame, and an arſenical ſmell, and by diſtillation, orpiment, or realgar, it is not magnetic, either before or after calcination, it contains much more of arſenic than of ſulphur. It is analyſed by digeſtion in marine acid, to which the nitrous is gradually added, otherwiſe the ſulphur would be deſtroyed. See N° 34.

Species. XX.

Mineralized by Arſenic ſingly.

Miſpickel. Speiſs of the Bohemians.

33. Its colour is generally of a bright white, reſembling a mixture of ſilver and tin, rarely

variegated like a pidgeons neck, and is not easily altered by exposure to the air. Its form either granular, cuspidated, cuneiform, prismatic or rhomboidal. It is magnetic neither before nor after calcination, is soluble in acids, affords arsenic by distillation, in the proportion of 30 or 40 per cent, and sometimes contains a small proportion of copper and silver. It is frequently mixed with other metallic ores, and often found in indurated clay, quartz, spar, shoerl, &c.

34. When iron contains less than $\frac{1}{16}$ of arsenic, it is magnetic, *Scheff.* §. 300, therefore if the calcination be pushed so far, the iron will remain magnetic. It may be analysed by solution in the marine acid, which will take up the iron and leave the arsenic, or by solution in aqua regia, which will take up both, but water being added, will precipitate the arsenic and leave the iron. The silver will remain in the form of horn silver, and the copper may be separated by the methods already mentioned.

Species XXI.

Combustible Iron Ore.

35. Of this kind Mr. *Cronsted* mentions two varieties, one, of which the greater part is

is volatil, in a ſtrong heat long continued, and ſeems to contain iron, plumbago, and coal intimately mixed. The other burns with a languid flame, loſes about $\frac{1}{5}$ of its weight, reſembles pit-coal, but is ſomewhat harder, and yields about 30 per cent of iron.

SPECIES XXII.

Mineralized by the Vitriolic Acid.

36. This has been mentioned under the head of ſaline ſubſtances.

Uncertain Mineralizations.

SPECIES XXIII.

Iron Blende.

37. This is ſaid by Mr. *Monnet* to be a ſtone of a grey iron colour, formed of diverging laminæ, of great hardneſs and a metallic appearance, but inſoluble in acids, and infuſible in the ſtrongeſt fire, *Mineral.* 356. Sometimes this ſtone contains arſenic, in this caſe it blackens by expoſure to the air.

SPECIES XXIV.

Wolfram.

38. This ſtone which is generally found in tin mines, is of a black or brown ſhining colour,

colour, of a radiated or foliated texture, of a moderate hardnefs, and fometimes fo brittle, as to be eafily broken between the fingers, but very weighty fince its fpecific gravity is 7,119; when fcratched it fhews a red trace, which diftinguifhes it from tungften. It is fcarcely foluble in acids, and of very difficult fufion. According to *Lehman*, it confifts of filiceous Earth, calx of iron, and a fmall proportion of that of tin, *Chym. Schrift.* 356, and from his experiments, I am inclined to think it contains manganefe.

SPECIES XXV.

Native Pruffian Blue.

39. It confifts of clay mixed with iron, and fome unknown tinging fubftance, generally found in fwampy grounds or bogs. It is at firft white but when expofed to the air, it becomes either of a light or deep blue. When heated, it turns greenifh, and emits a flight flame, and then becomes red and magnetic, it is foluble both in acids and alkalis, but the latter precipitate it from the former, and the former from the latter; the precipitate is at firft greenifh, but gradually affumes a white hue, but recovers its blue tinge if it be fteeped in vegetable aftringents, *Bergm. Sciagr.* §. 206. *Phil. Tranf.* 1768

1768. The Earth of *Beuthnitz* in *Silesia*, mentioned in the *Memoirs* of *Berlin* for the year 1757, seems to belong to this species, it contains about $\frac{1}{4}$ of its weight of iron.

Species XXVI.

Green Earth of Verona and Normandy.

Terre Verte.

40. This is used as a pigment, and contains iron in some unknown state, mixed with clay, and sometimes with chalk and pyrites; allum and selenite are also accidentally found with it. It is difficultly soluble in acids, is not magnetic before calcination, and becomes of a coffee colour when heated. It is said to afford about 40 per cent of iron. If iron be precipitated from vinegar, by the arsenical acid, the precipitate will be green, 36 *Mem. Stock.* and it will preserve its colour though exposed to the air. Iron precipitated from the marine acid by lime water, is frequently green, and green fluors are known to derive their colour from this metal. The molybdenous acid gives also a green colour to iron, but this fades.

Of

Of the Analysis and Essay of Iron Ores.

In the moist Way.

41. The general method of analysing in the moist way the *calciform ores*, which do not contain much earth or stony matter, is, after reducing them to a subtil powder, to dissolve them in the marine acid, and precipitate them by the *Prussian* alkali; the quantity of alkali used discovers that of iron in its metallic state, which the ore would afford, as already mentioned in the analysis of earths, or the precipitate washed and dried may be weighed; its weight divided by 6 (subtracting 4 per cent. for the iron already contained in the alkali) gives the quantity of iron in its metallic state which the ore contains.

But if the iron be united to any considerable proportion of zinc or manganese, its estimation by the above methods is not sufficiently accurate; therefore the *Prussian* blue must be calcined to redness, and the calx treated with dephlogisticated nitrous acid, which will then take up only the calx of zinc: when this is separated, the calx should be again treated either with nitrous acid, with the addition of sugar, or still better, with the acetous acid, either of which will separate the manganese, if any; the remaining calx of

of iron may then be diſſolved by the marine, and precipitated by the mineral alkali, or it may be further calcined, and then weighed. The annexed tables ſhew the correſpondence betwixt the weight of the calx, or the precipitates with that of iron in its metallic ſtate. See alſo Chap. 15. N°. 18.

42. To analyſe the *white calcareous iron ore*, it ſhould be firſt calcined to find the weight of the fixed air and water, then thrown into dephlogiſticated nitrous acid, and ſhaken for a few minutes until the menſtruum begins to acquire a yellow colour; it will then contain the calcareous earth only, which may be precipitated by the mineral alkali, and weighed; the reſiduum well calcined may be treated with the acetous acid as above.

43. According to Mr. *Rinman*, the contents of this ore may be conjectured very nearly from its ſpecific gravity; for as 80 is to 100, ſo is the ſpecific gravity of this ore to its contents per cent.

44. The pyritous, argillaceous and ſtony ores are analyſed by ſolution in marine acid, to which, if neceſſary, a little of the nitrous may be added: this digeſtion ſhould be continued as long as the menſtruum acquires a yellow

a yellow colour; coction may be requisite at the end.

45. Many ores, which are difficultly soluble before calcination, become easily soluble after they are calcined.

46. To discover siderite in an ore, it should be dissolved in dilute vitriolic acid; the solution, after standing some hours, will deposit a white calx, if siderite be contained in it.

In the dry Way.

47. Mr. *Morveau* recommends the following flux for all iron ores: 8 parts pulverised glass, 1 of calcined borax, and $\frac{1}{2}$ of charcoal, well mixed; of this flux he takes two parts, or, if the ore be very poor, 3 parts, and 1 of the ore, and places them in a crucible, lined with a mixture of a little clay, and pounded charcoal $\frac{1}{8}$ of an inch thick, to which a cover is luted: this he places in a smith's forge, and urges it with a strong heat for half an hour; to find whether the ore requires calcination, he institutes this trial with equal weights of the ore calcined and uncalcined, and compares the results; the weight of the ore should not exeed 60 grains.

48. Mr. *Bergman* essays the white sparry iron ore by placing it in a crucible lined with char-

coal ½ an inch thick at bottom, and ⅛ on the ſides, ſimply covering it with calcined borax, luting on this another crucible, which he alſo expoſes to the heat of a ſmith's forge.

49. Argillaceous and ſiliceous iron ores may be eſſayed in the following manner: take of the ore 4 parts, quick lime 1,25, fluor ſpar 1,25, powdered charcoal 1, decrepitated common ſalt 4; the whole, being well mixed, place in a crucible lined with charcoal, to which a cover ſhould be luted, and the lute being dry, commit it to a ſmith's forge, giving a moderate heat for ¼ of an hour, and the ſtrongeſt for the remainder of the hour; if the lime be ſlacked, double the quantity muſt be uſed. 6 *Crell. Nev. Entdeck.*

50. Calcareous ores may be treated in the ſame manner, except that inſtead of quick lime double the quantity of fluor ſhould be uſed.

51. Pyritous ores are alſo eſſayed nearly in the ſame manner; the proportions being 4 parts of the ore previouſly roaſted, 2 of quick lime, 2 of fluor, 1½ of charcoal, and 4 of decrepitated common ſalt. *Ibid.*

52. Iron ores, which, though at firſt bright in their fracture, ſoon grow black by expoſure to the air, contain much manganeſe.

53. To find whether iron or its ore contains manganeſe, let a ſmall quantity of it be heated white in a crucible, and on this project 5 times its weight of purified nitre, taking care that no coal or aſhes ſhould get into the crucible: when all is cold, the upper part of the crucible will be covered with a greeniſh or bluiſh cruſt, if the iron contain manganeſe. 3 *Bergm* 66. When the ſolution of iron in the marine acid is of a red colour, this alſo denotes the preſence of manganeſe, though that colour ſoon changes to a yellow, by extracting phlogiſton from the martial part.

54. Mr. *Bergman* gives alſo a method of finding whether the ore affords coldſhort or redſhort iron. He melts the regulus obtained from the ore with ¼ of its weight of good malleable iron in a crucible lined with charcoal, and well covered. If the regulus thus obtained be brittle when cold, the ore affords coldſhort iron, or if it cracks under the hammer in a white heat, it is redſhort. 3 *Bergm.* 46.

CHAP. VI.

Tin.

1. The colour of tin is too well known to need being deſcribed; its ſpecific gravity is

from 7 to 7,45; the lighteſt is the pureſt; it melts the moſt readily of all metals; it is eaſily diſſolved in ſpirit of ſalt or aqua regia, and its ſolution is precipitated blue or purple by that of gold.

Species I.

Native.

2. The exiſtence of native tin has long been queſtioned, but it has undoubtedly been found ſome years ago in *Cornwall* in the form of thin flexible laminæ iſſuing out of a matrix of quartz, or regularly cryſtalized. *Phil. Tranſ.* 1766. p. 37. and Mr. *Quiſt*, a very competent judge, atteſts its purity in the *Memoirs* of *Stockholm* for the ſame year.

3. To aſcertain its purity, Mr. *Bergman* adviſes dephlogiſticating it by the nitrous acid. 140 gr. of this calx waſhed and dried are equivalent to 100 of tin in its metallic form; the ſolution will take up the copper, and a ſmall proportion of iron which the tin may contain, and theſe again may be ſeparated by boiling; if there be any arſenic, it will be found in the waſhings.

SPECIES II.

Calciform Ores.

4. Theſe ores are remarkable for their great weight, their ſpecific gravity being from 5,955 to 6,75: they may be reduced to 4 Varieties.

I. VARIETY.

Tin Spar, white Tin Ore.

5. It is generally of a whitiſh or grey colour, ſometimes greeniſh or yellowiſh, ſemi-tranſparent and cryſtalized in a pyramidical form, or irregularly: it was formerly thought to contain arſenic; but Mr. *Margraaf* found it the pureſt of all tin ores, 1 *Margr.* 188, 189, though it is ſaid to contain ſometimes a mixture of calcareous earth; its ſpecific gravity is 6,007.

II. VARIETY.

Opake, brown or black Tin Ore.

6. This is alſo cryſtalized and imbodied in a ſtony matrix of quartz, fluor or mica, or mixed with white or yellow pyrites, or in ores of lead or zinc, cobalt, wiſmuth or iron; when theſe cryſtals are large, they are called by the Germans *zingraupen*, and when ſmall

zin zwitter; the black are reckoned the richest, and afford about 80 per cent. of tin; they all contain a mixture of iron.

7. The ore called *weiſs zingraupen* is that which was mentioned under the calcareous genus by the name of *tungſten*; it contains no tin. When any arſenic is found in tin, it proceeds from the matrix, for tin itſelf is never mineralized by it; and for the ſame reaſon zinc is ſometimes found in tin.

8. The ſpecific gravity of this ore is 6,75. *Mem. Stock.* 1778, p. 321.

III. Variety.

Reddiſh or reddiſh yellow Tin Ore, Garnet Tin Ore.

9. This conſiſts of ſmall cryſtals ſemi-tranſparent or opake, and ſometimes it is found of a ſpherical form, ſtriated, and reſembling hæmatites or zeolyte; its ſpecific gravity is from 5 to 5,8; it contains more of iron than of tin.

IV. Variety.

Tin Stone, Zinſtein of the Germans, Tinberg of the Swedes.

10. The preceding varieties conſiſt for the moſt part of metallic particles; the preſent, chiefly

chiefly of ſtones or ſands of different ſorts, which contain calx of tin inviſibly diſſeminated through them; their ſpecific gravity, when the proportion of tin is of any importance, is conſiderable; they may be of any colour, blue, grey, black and brown are the commoneſt; they are called *Lodeſtones*.

12. Tin ores are very ſcarce, not being hitherto found in any conſiderable quantity, except in the *Eaſt Indies*, *Cornwall*, *Bohemia* and *Saxony*.

13. It is remarkable that tin has not as yet been found in any ſtones of the calcareous genus, except fluors, but only in thoſe of the ſiliceous or agillaceous kind.

Species III.

Mineralized by Sulphur.

14. This was lately diſcovered by Mr. *Bergman* among ſome minerals which he received from *Siberia*. He obſerved two ſorts of it analogous to the two artificial combinations of tin with ſulphur; one nearly of the colour of zinc, and of a fibrous texture, which contained about twenty per cent. of ſulphur, and the remainder tin; the other inveloped the former like a cruſt, reſembled *aurum muſivum*, and contained about 40 per cent. of

ſulphur, a ſmall proportion of copper, and the remainder tin. *Mem. Stock.* 1781, p. 328.

15. To eſſay tin ores in the *liquid way* has hitherto been thought impracticable; however, Mr. *Bergman* has deviſed the following method, which is generally ſucceſsful. Let the tin ore, well ſeparated from its ſtony matrix by waſhing, and reduced to the moſt ſubtile powder, be digeſted in concentrated oil of vitriol in a ſtrong heat for ſeveral hours, then when cool add a ſmall quantity of concentrated marine acid, and ſuffer it to ſtand for one or two hours; then add water, and when the ſolution is clear pour it off, and precipitate it by fixed mineral alkali. 131 gr. of this precipitate waſhed and dried are equivalent to 100 of tin in its reguline ſtate, if the precipitate conſiſts of pure tin; but if it contains copper or iron, it ſhould be calcined for one hour in a red heat, and then digeſted in nitrous acid, which will take up the copper, and afterwards in marine acid, which will ſeparate the iron.

16. In the *dry way*, theſe ores, after pulverization and ſeparation of the ſtony matter by waſhing, are to be melted with a mixture of double their weight of a flux, conſiſting of equal parts of pitch and calcined borax, in a crucible

crucible lined with charcoal, and to which a cover is luted; fuſion ſhould be ſpeedily procured.

17. Mr. *Bergman* recommends a mixture of one part of the ore with two of tartar, 1 of black flux, and $\frac{1}{2}$ part of roſin: this is to be divided into three parts, and each ſucceſſively projected into a crucible heated white, and immediately covered after the foregoing portion ceaſes to flame; the whole operation takes up but 7 minutes or leſs. *Sheff.* §. 304.

CHAP. VII.

Lead.

1. This metal is ſufficiently diſtinguiſhable by its colour, which is well known, its ſpecific gravity, which reaches from 11,3 to 11,479, its great ſoftneſs and eaſy fuſibility. It is more or leſs ſoluble in all acids, and particularly in the nitrous, and all its ſolutions have a ſweetiſh taſte, it is precipitable from the nitrous by the vitriolic or marine, and from the marine alſo, by the vitriolic.

SPECIES I.

Native Lead.

2. It is ſaid to have been found in *Monmouthſhire*

mouthshire in small pieces, *Phil. Trans.* 1772, p. 20, also in the *Vivarais*, *Gensanne hist. Languedoc*, vol. 3. p. 208. *Henckel* also mentions it in his *Flora Saturnisans*. If it contains copper, this latter may be detected by a plate of iron immersed in its solution in nitrous acid, and the presence of silver, if any be contained in it, will be discovered by a plate of copper.

Species II.

Mineralized by the Aerial Acid.

Calciform Ores.

3. Of these we may distinguish 5 varieties, all easily soluble in nitrous acid, and with effervescence if heat be used, and also in expressed oils; all contain a little iron, but never silver.

I. Variety.

White, Lead Spar, Lead Ochre, Native Ceruss.

4. *Lead Spar* is sometimes transparent, but generally opake, and crystalised in regular forms, of a laminar or striated texture. Lead ochre, or native ceruss is the same substance, but in a loose form, or indurated and shapeless; sometimes it is found in a silky form. Both contain a little iron, and sometimes calcareous

calcareous earth and argill. *Jacquin's Miſcell.* 157. 3 *Roz.* 348. both grow red or yellowiſh when ſufficiently heated. They efferveſce with acids, and afford from 60 to 80 or 90 per cent. of lead; both are found in *Brittany*, *Lorrain*, *Germany*, and *England*.

II. Variety.

Red, Brown, or Yellow.

5. This is alſo found either regularly cryſtalized, or in ſhapeleſs maſſes, or in powder. It differs from the former only by containing more iron. That in powder contains a mixture of clay. It affords about 70 or 80 per cent. of lead.

III. Variety.

Green.

6. Either cryſtalized in needles as in *Brittany*, or in a looſe powder as in *Saxony*, but moſtly adhering to, or inveſting quartz. It owes its colour to iron, and ſeldom contains copper. 3 *Lin. Von Gmel.* 225. 10 *Roz.* 375.

IV. Variety.

Bluiſh.

7. This is alſo ſometimes cryſtalized, ſometimes

times amorphous. It owes its colour to a mixture of copper.

V. VARIETY.

Black.

8. The moſt uncommon of all, and occurs either cryſtalized, or of an indeterminate form.

9. Theſe ores, when freed as much as poſſible from earthy matter, are eſſayed in the moiſt way, by ſolution in ſpirit of nitre. The ſolution being boiled, depoſits the calx of iron. If the lead be then precipitated by an aerated mineral alkali, 132 gr. of the precipitate, will denote 100 of lead in its metallic ſtate. If the ore contains copper, it may be ſeparated by digeſting the calx in volatil alkali; if it be ſuſpected to contain ſilver and copper, then, after the ſeparation of the copper, the calx ſhould be rediſſolved in nitrous acid, and both the lead and ſilver precipitated by the marine acid; the marine ſalt of lead is rediſſoluble in 30 times its weight of boiling water, but that of ſilver will remain undiſſolved, or that of ſilver may be ſeparated by cauſtic volatile alkali.

10. In the dry way, theſe ores are reducible by the ſimple addition of phlogiſton and fuſion.

SPECIES III.

Mineralized by the Vitriolic acid.

11. According to Mr. *Monnet*, this ſometimes occurs in the form of a white ponderous calx, ſoluble in 16 or 18 times its weight of water. It does not effervеſe, nor is it ſoluble in other acids; it may be reduced by laying it on a burning coal. It originates from the ſpontaneous decompoſition of ſulphurated lead ores. *Mon. Mineral.* 371. According to Dr: *Withering*, it is found in great quantity in the iſland of *Angleſy*, but united to iron, and not reducible by the blow pipe or charcoal, he promiſes an exact analyſis of it, this is of a yellow colour, and mixed with clay.

SPECIES IV.

Mineralized by the Phoſphoric acid.

12. This was lately diſcovered by Mr. *Gahn*; it is of a greeniſh colour, by reaſon of a mixture of iron; it does not effervеſce with acids.

To eſſay it, a ſolution of it in nitrous acid muſt be had, with the aſſiſtance of heat. From this ſolution, the lead is to be precipitated by the acid of vitriol. 137 gr. of this precipitate, waſhed and dried, are equivalent to

to 100 of lead in its metallic ſtate. The decanted liquor evaporated to dryneſs, affords the phoſphoric acid.

Species V.

Mineralized by Sulphur, with Silver and a little Iron.

Galena, Potter's Ore, Bley Glanz, Bley Schweiſ, of the Germans.

13. It is the commoneſt of all lead ores, of a bluiſh dark lead colour, formed of cubes of a moderate ſize, or in grains of a cubic figure, whoſe corners have been cut off; its texture is lamellar, and its hardneſs variable; the hardeſt ſort containing a greater mixture of iron or quartz; that in grains is thought to be the richeſt in ſilver; but the richeſt contains only about 1 or 1,5 per cent. that is, 12 or 18 ounces per quintal, the pooreſt about 60 gr. Ores that yield about ½ an ounce of ſilver per quintal, are barely worth the coſt of extracting it; the proportion of ſulphur to lead in this ore is alſo variable within the limits of 15 and 25 per cent. that which contains leaſt is called *Bley Schweiſ*, and is in ſome degree malleable. The proportion of lead is from 85 to 60 per cent. by reaſon of an accidental mixture of quartz, that of iron is

is generally very ſmall. Dr. *Watſon* remarks, that the ores which are pooreſt in lead, are often the richeſt in ſilver. Mr *Monnet* aſſerted, that ſulphurated lead ores are inſoluble in nitrous acid, but Dr. *Watſon* has ſhewn that dilute nitrous acid diſſolves them compleatly. 3 *Wats*. 228. The ſpecific gravity of Galena, is from 7,000 to 7,780; when melted it yields a yellow ſlag.

14. To analyſe this ore in the moiſt way, let it be diſſolved by boiling in the dilute nitrous acid, the ſulphur and inſoluble ſtony parts and calx of iron will remain undiſſolved; the iron may be afterwards ſeparated by digeſtion in marine acid, and the ſulphur by digeſtion in cauſtic fixed alkali, the reſiduum weighed before and after will ſhew the proportion of each.

15. The nitrous ſolution will contain the lead and ſilver; this ſolution ſhould be precipitated by the mineral fixed alkali, and the precipitate waſhed in cold water, dried and weighed. After weighing it ſhould again be digeſted in cauſtic volatil alkali, which will diſſolve and take up only the calx of ſilver, the reſiduum being again dried and weighed, gives the proportion of the calx of lead, of which 132 gr. are equivalent to 100 of lead in its metallic ſtate; and the difference between the

weight

weight of the precipitate, before and after the application of the volatil alkali, gives the quantity of the calx of ſilver, of which 129 gr. are equivalent to 100 of ſilver in its metallic form.

16. If the ore contains any ſoluble matrix, which very ſeldom happens, it ſhould firſt be ſeparated by boiling in diſtilled vinegar. 2 *Bergm.* 424.

17. In the dry way this ore may be eſſayed by melting it with $\frac{1}{3}$ of its weight of filings of iron.

Species VI.

Mineralized by Sulphur, with Silver and Regulus of Antimony.

Antimonial Lead Ore, Sproterz, Stripmalm.

18. Its colour is the ſame as that of Galena, but its texture is different, being radiated, filamentous, or ſtriated; when heated it yields a white ſmoke; it affords from 40 to 50 per cent. of lead, and from $\frac{1}{2}$ an ounce to 2 ounces of ſilver per quintal.

It is eſſayed in the *liquid way*, by ſolution in concentrated ſpirit of nitre, which dephlogiſticates the regulus, and leaves it in the form

form of a calx. 138 gr. of this calx are equivalent to 100 of the regulus. Or ſtill better, by ſolution in ſpirit of ſalt which diſſolves both the lead and regulus, and leaves the ſulphur and ſtony matter which are ſeparable, as ſhewn in N° 14. If water be poured on the ſolution, the calx of antimony will be ſeparated.

Species VII.

Mineralized by Sulphur, with Silver and a large Proportion of Iron.

Pyritous Lead Ore.

20. This is of a brown or yellowiſh colour, of an oblong or ſtalactitical form, friable, and of a lamellar, ſtriated or looſe texture; it affords at moſt 18 or 20 per cent. of lead, which flows by barely heating it, as the iron detains the ſulphur; it is no more than a mixture of galena with the brown pyrites, Chap. 5. N° 31.

Species VIII.

Mineralized by Sulphur and Arſenic, with Silver.

Red Lead Spar.

21. Lately diſcovered in *Siberia*; externally it is of a pale and internally of a deep

 red,

red, and for the moſt part cryſtalized in rhomboidal paralellipipeds, or irregular pyramids. According to *Lehman* it contains ſulphur, arſenic, and about 34 per cent. of lead, and according to Mr. *Pallas* alſo ſilver. *Pallas Reiſe.* 2 *Theil.* p. 274.

Species IX.

Stony or ſandy Lead Ore.

22. This conſiſts either of the calciform lead ores, or galena, intimately mixed and diffuſed through ſtones or earths chiefly of the calcareous kind.

23. It is analyſed in the *moiſt way* in the manner already deſcribed, and in the *dry way*, if the matrix be calcareous, by adding the fluor ſpar, or if ſiliceous, the black flux with a little iron.

24. Ores of lead are moſt frequently found among ſtones of the calcareous or barytic genus.

CHAP. VIII.

Mercury.

1. It were ſuperfluous to mention its leſs obvious characters, as its liquidity alone ſufficiently

ficiently diſtinguiſhes it from all other metallic ſubſtances.

SPECIES I.

Native.

2. Native mercury has frequently been found in the mines of *Idria*, *Friuli*, *Lower Auſtria*, *Deuxponts*, &c. flowing from a ſhiſtoſe or quartzy matrix, and probably mixed with ſome other metal, as its globules are not perfectly ſpherical. In *Sweden* and *Germany* it has been found united to ſilver in the form of a ſomewhat hard and brittle amalgam. *Mon. Mineral.* 387. 3 *Lin. von Gmel.* 41. It has alſo been obſerved viſibly diffuſed through maſſes of clay, or ſtone of a white, red, or blue colour and great weight, in *Spain* and *Idria*, and in *Sicily* in beds of chalk. *Borch Sicil. Mineral.* p. 508.

3. To examine its purity in the moiſt way, Mr. *Bergman* recommends ſolution in the nitrous acid; for, as he well remarks, the metals it is moſt likely to be mixed with are gold, ſilver and biſmuth, as they are moſt frequently found native: in this ſolution, gold, if any be contained in the mercury, will remain undiſſolved; biſmuth may be ſeparated by the affuſion of water, but the ſilver and

mercury will remain, and both ſhould be precipitated by the marine acid; the precipitate waſhed in cold water and dried ſhould be weighed, and then digeſted in hot water, the marine mercury will be diſſolved; the reſiduum, containing only the marine ſilver, ſhould again be waſhed, dried and weighed; the difference between the former and preſent weight gives the quantity of marine mercury, and the metallic contents of each may be deduced by the rule of proportion from the 2d table.

SPECIES II.

Mineralized by the aerial Acid.

Native precipitate per ſe *or Calx of Mercury.*

4. This is ſaid to have been lately found in *Idria* in hard compact maſſes of a browniſh red colour, and granular texture, mixed with ſome globules of native mercury. By diſtillation it is recovered in its running form. 100 parts of it afford 91 of running mercury. *Roz. Jan.* 1784, p. 61.

SPECIES III.

Mineralized by the Vitriolic and Marine Acids.

Vitriol and Marine Salt of Mercury.

5. Mr. *Woulfe* firſt diſcovered theſe ſalts at *Obermoſchel*, in the dutchy of *Deuxponts:* they

they have a ſpar-like appearance, and are either bright and white, or yellow or black, mixed with cinnabar in a ſtony matrix; theſe well mixed with $\frac{1}{3}$ of their weight of vegetable alkali, afforded him cubic and octagonal cryſtals, that is, ſalt of ſilvius and tartar vitriol. *Phil. Tranſ.* 1776. The marine ſalt of mercury is in the ſtate of ſublimate corroſive.

6. Mr. *Bergman*'s ingenious and truly ſcientific method of diſcovering the proportion of theſe ſalts is nearly as follows: Firſt, by trituration and digeſtion in marine acid he expells the vitriolic, the mercury uniting preferably with the former of theſe acids; the whole is then diſſolved in a ſufficient quantity of hot water; into this ſolution he drops that of marine baroſelenite until no further precipitation is perceived; the true or vitriolic baroſelenite thus formed, being waſhed and dried, contains 13 per cent. of real vitriolic acid: now vitriol of mercury contains 19 per cent. of real acid. Hence the weight of the former being found, that of the latter will eaſily be known; for ſuppoſing the weight of the baroſelenite to be 100 gr. then it will contain 13 of vitriolic acid; and ſince 19 of vitriolic acid go to 100 gr. of vitriol of mercury, 13 will go to 68,4; then if the weight of the vitriol of mercury be

ſubtracted from that of the whole of the ore, the remainder gives the weight of the marine ſalt of mercury, and this being ſublimate corroſive, 100 gr. of it will contain 77 of mercury, and ſo in proportion.

Species IV.

Mineralized by Sulphur.

Native Cinnabar.

7. This is of different ſhades, from a yellowiſh to a deep red, and is found either pure in hard, friable maſſes, either ſhapeleſs or cryſtalized in cubes, and ſometimes tranſparent, or intermixed with clay or ſtone, or interſperſed through the ores of other metals, particularly thoſe of ſilver or copper, or martial pyrites; its texture is either radiated, ſtriated, ſcaly or granular. 100 parts of cinnabar contain about 80 of mercury, and 20 of ſulphur; artificial cinnabar contains a little more ſulphur, and hence its colour is darker; its ſpecific gravity is about 7,000; it ſublimes in cloſe veſſels, and in open, it is decompoſed and volatilized when ſufficiently heated; it is inſoluble in the nitrous and vitriolic acids; it is ſometimes contained in very heavy red or browniſh red ſtones or ſand.

8. To analyſe it in the moiſt way, its ſtony matrix

matrix ſhould firſt be diſſolved in nitrous acid, and the cinnabar being diſengaged ſhould be boiled in 8 or 10 times its weight of aqua regia, compoſed of 3 parts nitrous and 1 of marine acid; the mercury may then be precipitated from the ſolution in its running form by zinc.

9. In the dry way the mercury is obtained in its running form by diſtilling the cinnabar with $\frac{1}{3}$ of its weight of filings of iron, or even without iron, if the matrix of the cinnabar be calcareous.

Species V.

Mineralized by Sulphur with Copper.

Black Ore of Mercury.

10. According to *Cronſted* and *Linneus* this ore is of a blackiſh grey colour, glaſſy texture, and decrepitates ſtrongly when heated; the cinnabar is volatilized, and the copper remains, and may be diſtinguiſhed by the uſual teſts.

Species VI.

Pyritous Mercurial Ore.

11. Mr. *Monnet* relates, that he found in *Dauphiné* a grey or whitiſh friable ſubſtance,

100 parts of which afforded 1 of mercury, ½ of ſilver, and the remainder iron, cobalt, ſulphur and arſenic. *Mineralog.* p. 392.

12. Cinnabar mixed with arſenic or realgar is ſaid to be found in *Japan.* 3 *Lin. von Gmelin*, p. 65. At *Morsfeld*, cinnabar and the white calx of arſenic preſent themſelves in the ſame rock. *Ibid.*

CHAP. IX.

Zinc.

1. Zinc is the moſt malleable of all the ſemi-metals; its colour is nearly the ſame as that of lead; its ſpecific gravity is from 6,9 to 7,24; it is ſoluble in all acids, and its ſolution is colourleſs; it melts at a lower heat than ſilver or copper, but a higher than lead or tin, and at the ſame time inflames and ſublimes, forming a light white calx, called flowers of zinc, which are very fixed in fire, and ſoluble in acids.

SPECIES I.

Native.

2. This has not as yet been obſerved; that mentioned by *Bomare* appears to have been produced by art.

Mineralized.

Mineralized.

3. All the ores of zinc tinge plates of copper when ſtratified with them and charcoal, only the ſulphureous require previous torrefaction.

SPECIES II.

Mineralized by the aerial Acid.

Calciform Ores.

Of theſe there are 4 Varieties.

I. VARIETY.

Pure Calx of Zinc, Vitreous Zinc Ore, Zinc Spar.

4. Of a whitiſh, grey, bluiſh grey or yellowiſh colour, and of a hardneſs generally ſufficient to ſtrike fire with ſteel; in its fracture it reſembles quartz, amorphous, ſtalactitical or cryſtalized in groups, and weighty; by calcination it loſes $\frac{1}{3}$ of its weight, without emitting a ſulphureous or arſenical ſmell, and is infuſible in the ſtrongeſt heat either ſingly or with mineral alkali, but eaſily fuſible with borax or microcoſmic ſalt. In the mineral acids it is ſoluble with effervefcence, and with the vitriolic affords vitriol of zinc. 100 gr. of this ore contains about

65 of the calx of zinc, 28 of aerial acid, 6 of water, and 1 of iron, and ſometimes a little of ſilex. 2 *Bergm. De Min. Zinci.*

5. *Note*, Mr. *Bergman* ſuſpects the ſubſtance called zinc ſpar by Baron *Born* to be a different ſubſtance. Mr. *Bindheim* found it inſoluble in acids before calcination, and in the dry way infuſible with the three uſual fluxes, but after calcination it becomes ſoluble in acids. 4 *Berlin Schrift*. 399.

II. Variety.

Mixed with a notable Proportion of Iron.

Tutenago.

6. Mr. *Engeſtrom*, in the Memoirs of *Stockholm* for the year 1775, has given us an analyſis of an ore of this ſort from *China*; it was of a white colour, interſperſed with red ſtreaks of calx of iron, and ſo brittle as to be eaſily broken betwixt the fingers; in the dry way it exhibited the ſame appearances as the former Variety, except that it loſt no part of its weight; it was ſoluble in the mineral acids, particularly with the aſſiſtance of heat, and with the vitriolic afforded vitriol both of zinc and iron; the quantity of fixed air was ſo ſmall as to be abſorbed by the ſolution; it contained in various ſpecimens from 60 to 90 per

per cent. of zinc; the remainder was iron and a ſmall proportion of argill. Mr. *Bindheim* alſo diſcovered this Variety in *Germany*, and found it to conſiſt of zinc, a little iron and ſilex. 4 *Berl. Schrift.* 400.

III. Variety.

Mixed with Iron and Clay in various Proportions.

Calamine.

7. Its colour is white, grey, yellow, brown or red, not ſo brittle as the 2d Variety, and of various degrees of hardneſs, though ſcarce ever ſo hard as to ſtrike fire with ſteel; its texture equable or cellular, and its form either amorphous, cryſtalized or ſtalactitical; when calcined it loſes no part of its weight, except it be mixed with charcoal, and then flowers of zinc ſublime; it is ſoluble in acids, and with the vitriolic affords vitriol of iron as well as of zinc, which ſhews the iron it contains is not much dephlogiſticated. The ſpecific gravity of the beſt ſort, that is, the grey, is 5,000: 100 parts of this afforded Mr. *Bergman* 84 of calx of zinc, 3 of iron, 1 of argill. and 12 of ſilex; but in other ſpecimens theſe proportions are very different; ſome ores are ſo poor as not to contain above

4 per

4 per cent. of calx of zinc; a good ore ſhould afford at leaſt 30 per cent. and its ſpecific gravity be about 4,400 or 5,000.

8. Sometimes calamines contain a mixture of calcareous earth and lead. 3 *Lin. von Gmel.* 112. Moſt of the Engliſh calamines contain lead.

9. The firſt and ſecond Varieties are eaſily analyſed in the moiſt way, by diſſolving them in the dilute vitriolic acid; the ſilex, if any, will remain undiſſolved, and the zinc and iron are taken up, and may be ſeparated by adding a piece of zinc previouſly weighed, and boiling the ſolution; the iron will be precipitated; the ſolution, which then contains only zinc, ſhould be precipitated by aerated mineral alkali. 193 gr. of this precipitate are equivalent to 100 of zinc in its metallic form, from which the weight loſt by the inſerted zinc ſhould be ſubtracted; the weight of the fixed air and water may be collected by comparing the loſs of weight which the ore ſuffers by calcination and ſolution in acids.

10. The analyſis of the 3d Variety, or calamine, is more complex. Mr. *Bergman* gives us two methods of performing it. The firſt is to dephlogiſticate it in the nitrous acid with

with the aſſiſtance of heat and boil away the acid to dryneſs. Repeat this operation twice or thrice, uſing each time twice as much of the acid as the ore weighs; and, laſtly, diſſolve all that is ſoluble in a freſh portion of nitrous acid: by this means the zinc (and lead if any) with the argill, will be taken up, while the iron, being dephlogiſticated, will with the ſilex remain undiſſolved; if the ſolution contains lead, the marine acid will precipitate it; after which the vitriolic may be uſed to precipitate the calcareous earth, if any be contained in the ore, or the lead and other metals may be precipitated by adding a piece of zinc as in N° 9. The zinc may then be precipitated by the *Pruſſian* alkali, the weight of which divided by 5 gives that of zinc in its metallic form contained in the ore. The undiſſolved reſiduum ſhould be treated with three times its weight of concentrated vitriolic acid, and evaporated to dryneſs, and all that is ſoluble extracted with warm water; the iron ſhould be precipitated by the *Pruſſian* alkali, and the argill by the aerated mineral alkali, which ſhould alſo be added to the nitrous ſolution after the zinc is precipitated.

11. The ſecond method is ſhorter and more ingenious. He diſtills the vitriolic acid over calamine to dryneſs; the reſiduum he lixiviates

viates in hot water, what remains undiſſolved is ſilex ; to the ſolution he adds a cauſtic volatil alkali, which precipitates the iron and argill, but keeps the zinc in ſolution, as it is ſoluble in vitriolic ammoniac ; the precipitate he re-diſſolves in vitriolic acid, and ſeparates the iron and argill as before.

IV. Variety.

Mixed with a notable proportion of Silex.

Zeolytiform.

12. The real contents of this ſubſtance were firſt diſcovered by Mr. *Pelletier*, a moſt accurate Pariſian chymiſt. It was long taken for a zeolyte, being of a pearl colour, cryſtalized, ſemi-tranſparent, conſiſting of laminæ, diverging from different centers, and becoming gelatinous with acids. It was commonly called *zeolyte of Friburgh*, he found 100 gr. of it to contain from 48 to 52 of quartz, 36 of calx of zinc, and 8 or 12 of water.

Species III.

Mineralized by the Vitriolic Acid.

13. This has already been mentioned in the ſecond part.

Species

SPECIES IV.

Mineralized by Sulphur, by means of Iron.

Blende. Pſeudo-galena. Black Jack.

14. Of this there are ſeveral varieties, generally of a lamellar or ſcaly texture, and frequently of a quadrangular form, reſembling galena, they all loſe much of their weight when heated, and burn with a blue flame; their ſpecific gravity is inferior to that of galena. Almoſt all contain a mixture of lead ore, moſt of them exhale a ſulphureous ſmell when ſcraped, or at leaſt when vitriolic or marine acid is droped on them.

I. VARIETY.

Bluiſh Grey, and of a Metallic Appearance, Glanz Blende.

15. Its form is generally cubical or rhomboidal, its texture ſcaly or ſteel grained; by calcination it loſes nearly $\frac{1}{6}$ of its weight; after calcination it is more eaſily ſoluble in the mineral acids. 100 Parts of it afforded Mr. *Bergman* about 52 of zinc, 8 of iron, 4 of copper, 26 of ſulphur, 4 of water, and 6 of ſilex.

16. To analyſe this ore in the moiſt way, Mr.

Mr. *Bergman* firſt expelled the water, and part of the ſuphur by diſtillation; the reſiduum he treated with 3 times its weight of oil of vitriol evaporated to dryneſs, this lixiviated with warm water, left only 6 parts undiſſolved; in this ſolution a poliſhed plate of iron was boiled, which precipitated the copper. He then by means of the phlogiſticated alkali, precipitated the zinc and iron. This precipitate being calcined in an open fire, was ſeveral times treated with nitrous acid, evaporated to dryneſs, until the iron was perfectly dephlogiſticated; freſh nitrous acid being then added, diſſolved the zinc only, which being precipitated by the *Pruſſian* alkali, the proportion of zinc, in its metallic ſtate, was found as in N°. 10. Neither metal, as contained in the ore, is much dephlogiſticated.

II. Variety.

Black, Pecbeblende.

17. Of moderate hardneſs, does not give fire with ſteel, frequently cryſtalized, and then ſometimes tranſparent, or ſemi tranſparent; when pulverized, it gives a reddiſh powder, when heated it decrepitates, and if laid on a burning coal it emits a ſulfureous ſmell, and depoſes white and yellow flowers; it is not magnetic even after torrefaction, but loſes 25 per cent. of its weight. It is frequently

quently mixed with ſilver, arſenic, and other metals. 100 Parts of that of Danemora, examined by Mr. *Bergman*, exhibited 45 of zinc, 1 of regulus of arſenic, 9 of iron, 6 of lead, all ſlightly dephlogiſticated, 29 of ſulphur, 6 of water, and 4 of ſilex. 2 *Bergm.* 332.

18. This ore he analyſed in the moiſt way after the following manner, firſt, by diſtillation he obtained the water, regulus of arſenic, and part of the ſulphur; the reſiduum he boiled in marine acid, until all that was ſoluble was taken up. To the ſolution, after its filtration and ſome evaporation, he added vitriolic ammoniac, by whoſe decompoſition vitriol of lead was precipitated in ſome meaſure, and the remainder of it by further evaporation. This being ſeparated, the remainder was evaporated to dryneſs, and treated with nitrous acid, and at laſt, calcined to dephlogiſticate the iron; the calx of zinc only, was then diſſolved in the nitrous acid, and precipitated by the *Pruſſian* alkali.

III. Variety.

Red, or Reddiſh Brown. Röd Slag of the Swedes.

19. Its texture is generally ſcaly, ſometimes cryſtalized, and ſemitranſparent, it

gives fire with ſteel, it does not decrepitate nor ſmoke when heated, yet it loſes about 13 per cent. of its weight by torrefaction.

100 Parts of that of Sahlberg, contained by Mr. *Bergman's* analyſis, 44 of zinc, 5 of iron, 17 of ſulphur, 5 of water, 5 of argill, and 24 of quartz.

20. In analyſing this ore, the water and ſulphur were obtained as before, nitrous acid was ſeveral times diſtilled to dryneſs over the reſiduum, which was at laſt calcined, and again treated with the nitrous acid, which then left the iron and quartz and a little argill undiſſolved; the *Pruſſian* alkali precipitated the zinc from this ſolution, and after that, the aerated volatil alkali precipitated the argill. The undiſſolved reſiduum was treated with oil of vitriol diſtilled to dryneſs, which took up the calx of iron, and a ſmall proportion of argill. The *Pruſſian* alkali precipitated the iron, and the liquor being then evaporated, afforded a little alum and tartar vitriolate.

IV. Variety.

Phoſphoreſcent Blende.

21. Its colour is generally greeniſh, yellowiſh green, or red, of different degrees of tranſparency,

tranſparency, or opake; when ſcraped with a knife in the dark, it emits light, even in water, and after undergoing a white heat, when diſtilled *per ſe*, a ſiliceous ſublimate riſes, which ſhews it contains the ſparry acid, probably united to a metal ſince it ſublimes. It is almoſt wholly ſoluble in the marine acid in a boiling heat.

Mr. *Bergman* found 100 parts of that of *Scharſenberg*, to contain 64 of zinc, 5 of iron, 20 of ſulphur, 4 of fluor acid, 6 of water, and 1 of ſilex.

V. VARIETY.

Greyiſh yellow Blende.

22. This conſiſts of a mixture of blende, galena, and petrol, it contains about 24 per cent. of zinc; it is probably the ſame as the grey blende of *Monnet Mineral.* p. 400.

VI. VARIETY.

White Blende.

23. Found at *Silverberget Cronſt.* §. 230.

VII. VARIETY.

Yellow Blende.

24. Of the colour of wax, and ſemi-tranſparent, contains much ſulphur, *Mon.* 400.

25. In the dry way zinc is reduced by diſtilling its ore after torrefaction, with a mixture of its own weight of charcoal, in an earthen retort well luted, and a ſtrong heat; but by this method, ſcarce half the zinc it contains is obtained.

CHAP. X.

Regulus of Antimony.

1. Its colour is of a ſilvery white, its texture micaceous; its ſpecific gravity, when perfectly freed from iron, 6,860; it is remarkably brittle; the nitrous acid dephlogiſticates it, but holds only a very minute portion of it in ſolution. The marine has very little effect on it, but it is in a conſiderable degree, ſoluble in aqua regia formed of 7 parts marine, and 1 of nitrous acid; or in a mixture of the vitriolic and marine acids, or even of the vitriolic and nitrous. It melts long after it becomes red hot, emits a white ſmoke, and evaporates, forming white flowers; in cloſe veſſels it ſublimes without decompoſition.

Species I.

Native.

2. This was firſt diſcovered in the mine of *Sala* in *Sweden*, by that great metallurgiſt, Dr.

Dr. *Schwab*, in the year 1,748; it was composed of ſhining white irregular planes or *facettes*, reſembling *Miſpickel*, for which it was long taken, and in effect contained a mixture of arſenic; it has alſo been lately found in the mines of *Allemond* in *France* by Mr. *Mongez* the younger, alloyed with about 3 per cent. of arſenic. 23 *Roz.* 66.

3. Its purity may be examined by boiling it in a large quantity of nitrous acid, which will hold only the arſenic in ſolution.

Species II.

Mineralized by the aerial Acid.

Native Calx of Antimony.

4. This was alſo lately diſcovered by Mr. *Mongez*; it conſiſts of a group of white cryſtalized filaments diverging from a common center like zeolyte; urged with a blow pipe on charcoal it will diſſipate, which, together with its inſolubility in nitrous acid, is ſufficient to diſtinguiſh it.

Species III.

Mineralized by Sulphur.

Antimony.

5. Its colour is dark, or bluiſh grey; its

texture fibrous, cuneiform, ſolid, or lamellar; this laſt is ſometimes called *antimonial galena*; its form generally indeterminate, but ſometimes cryſtalized; it is the moſt fuſible of all ores; its ſpecific gravity is from 4 to 4,2, and when melted 4,7 or 5,000; it ſullies the fingers, and is very brittle; when gradually heated in a crucible it loſes about 22 per cent. of its weight, and becomes a grey calx; it is perfectly ſoluble in the marine acid with the aſſiſtance of heat; the nitrous only calcines the reguline part, and the vitriolic has but little effect on it; 100 parts of it contain 74 of regulus ſlightly dephlogiſticated, and 26 of ſulphur. 3 *Bergm.* 167.

6. It is analyſed by ſolution in aqua regia, conſiſting of 1 part nitrous, and 4 of marine acid; the ſulphur is found on the filter.

7. In the dry way antimony is ſeparated from the ſtony parts of its ore by diſtillation *per deſcenſum*; it is afterwards reduced to a regulus by gently roaſting it untill it loſes 22,5 per cent. of its weight, and then mixing the grey calx thus formed with twice its weight of black flux, and briſkly fuſing it in a covered crucible,

SPECIES IV.

Species IV.

Mineralized by Sulphur and Arſenic.

Arſenicated Antimony.

8. This is the ſame as the plumoſe ſilver ore mentioned among thoſe of ſilver, Species 11; beſides the colours there mentioned, it is found red or green, and then contains but a ſmall proportion of ſilver; its texture filamentous, very brittle and fuſible.

9. It is analyſed by ſolution in *aqua regia*; both the regulus and arſenic remain in the ſolution; the ſulphur is ſeparated by filtration; if the ſolution be then boiled with twice its weight of ſtrong nitrous acid, the regulus of antimony will be precipitated by dephlogiſtication, and the arſenic converted into an acid, which will remain in the liquor, and may be procured by evaporation to dryneſs.

10. If ſilver or copper be ſuſpected in this ore, it ſhould be treated in as Chap. 3. No. 25.

CHAP. XI.

Regulus of Arſenic.

1. Of a bright yellowiſh white colour, but ſoon loſes its luſtre, and grows black by expo-

ſure to the air; it is of a looſe ſtructure, very brittle, and of a lamellar texture; its ſpecific gravity is 8,310; if laid on a red hot iron it burns with a ſlight flame, white ſmoke, and garlick ſmell, is wholly volatilized, and tinges a plate of copper held over it white; it is eaſily ſoluble in the nitrous acid, more difficultly in the vitriolic, and ſcarce at all in the marine; boiling oils alſo diſſolve it; it detonates with nitre.

Species I.

Native, Scherben Cobalt, Fliegenſtein, Cobalt teſtacé.

2. Of a lead colour, of different degrees of hardneſs, friable, and of a ſcaly texture, ſeldom, if ever, cryſtalized; it poſſeſſes all the properties of the regulus above deſcribed.

3. It may be analyſed by ſolution in aqua regia; the ſilver, if any, will remain precipitated; the iron, of which it commonly contains a ſmall proportion, will remain in the ſolution; but if a ſmall quantity of water be added to the ſolution, the calx of arſenic will be precipitated, and the iron remain.

4. *Miſpickel*, which conſiſts of arſenic nearly in a reguline ſtate united with iron, has already

ready been mentioned among the iron ores, Species 20.

SPECIES II.

Mineralized by the aerial Acid.

Calciform arſenical Ore, native Calx of Arſenic, flos arſenici.

5. It is found either indurated in the form of white opake, tranſparent, or ſemi-tranſparent cryſtals, or in a looſe powdery ſtate, frequently mixed with native arſenic; it is volatil when heated, though leſs ſo than the regulus; it does not detonate with nitre, though an effervefcence ariſes.

Its ſpecific gravity is from 3,706 to 5,000; it is ſoluble in about 70 or 80 times its weight of water in the temperature of 60, or in 15 or 20 times its weight of boiling water; the ſolution turns tincture of turnſole *red,* and ſyrup of violets *green*; it is ſcarcely ſoluble in the vitriolic acid, ſomething more in the marine, and moſt perfectly in the nitrous diluted; when in a powdery form, it is called *flos arſenici,* and has been often taken for a calcareous earth.

6. *White pyrites,* which conſiſts of the calx of arſenic, mixed with ſulphurated iron, has been

been deſcribed among the iron ores. Species 19.

Species III.

Mineralized by Sulphur.

7. Of this there are two Varieties, the yellow and the red; both are ſublimable in cloſe veſſels, detonate with nitre, with fixed alkalis form a hepar, and are ſoluble in oils.

I. Variety.

Yellow, Orpiment.

8. This is rarely found cryſtalized. Baron *Born* once found it in a polyhædral form in a blue clay in *Hungary*; it is generally compoſed of ſhining, flexible laminæ like mica, more or leſs ſolid; its ſpecific gravity is about 3,315; it contains only about $\frac{1}{10}$ of its weight of ſulphur; it burns with a blue flame.

II. Variety.

Red, Realgar, Rauſchgelbe.

9. It is found either in ſhapeleſs or ſtalactitical maſſes, opake or ſemi-tranſparent, or tranſparent and regularly cryſtalized in octohædral pyramids or priſms, and then called *ruby of arſenic*; its ſpecific gravity is 3,225.

100

100 parts of it contain 16 of sulphur; nitrous acid soon destroys its redness.

10. To analyse these ores, they should be digested in marine acid, adding the nitrous by degrees to help the solution; the sulphur will be found on the filter; the arsenic will remain in the solution, and may be precipitated in its metallic form by zinc, adding spirit of wine to the solution. 2 *Bergm.* 442.

Species IV.

Calx of Arsenic diffused through Earths or Stones.

11. *Henckel* mentions a grey or bluish marl in which this calx was found; clay and calcareous stones are also sometimes impregnated with it; it is discovered either by the smell when laid on burning coals, or by lixiviation.

12. In the *dry way* calx of arsenic is separated from the ores which contain it by sublimation in a well luted retort, and a gradual heat, but some always remains, which cannot be expelled but by an open fire and the addition of charcoal.

13. White arsenic, that is, calx of arsenic, is reduced to a regulus, either by quickly melting it with a mixture of 2 parts soft soap,

ſoap, and two parts of mineral alkali, pouring it when in fuſion into a hot iron cone, or by mixing it with oil to the conſiſtence of a ſyrup, and then with a gradual heat diſtilling the whole to dryneſs; towards the end the regulus ſublimes, and may be made more perfect by a ſecond diſtillation with its own weight of oil; by reaſon of the offenſive ſmell the diſtillation ſhould be made in the open air.

CHAP. XII.

Biſmuth.

1. Biſmuth is of a reddiſh or yellowiſh white colour, of a lamellar texture moderately hard, and brittle; its ſpecific gravity exceeds that of any of the ſemi-metals, or even moſt of the intire metals, yielding only to that of platina, gold, mercury, lead and ſilver, being from 9,600 to 9,700; its fuſibility is nearly as that of lead; it is eaſily ſoluble in nitrous acid or aqua regia, but ſcarcely in the vitriolic, and ſtill leſs in the marine; its ſolution is colourleſs, and is precipitable by the addition of pure water.

2. 113 grains of this precipitate from nitrous acid, well waſhed and dried, are equivalent to 100 of biſmuth in its metallic form.

SPECIES. I.

Species I.

Native.

3. This is the commonest of all native metallic substances, and is generally found either in cubes or octagons, or of a dentritical form, or in that of thin laminæ investing the ores of other metals, particularly those of cobalt, from which it is easily distinguished and separated by its great fusibility; it is said to be sometimes alloyed with silver; if so, they are easily separated by solution in nitrous acid, and the addition of water, which precipitates only the bismuth, and leaves every other metal in the solution.

Species II.

Mineralized by the aerial Acid.

Native Calx of Bismuth.

4. When pure it is of a yellowish white colour, and either in a powdery form, or indurated like mortar; but it is frequently of a greenish yellow colour, being mixed with ores of other metals; the red and yellow part is most commonly cobalt ore, though it has often been mistaken for bismuth; it is frequently found in glittering particles interspersed through stones of various kinds; silver, iron, and other metals are also found in it; from all

all which it is ſeparable by ſolution in nitrous acid, as before explained.

Mineralized by the vitriolic Acid.

Wiſmuth Bluth.

5. This is ſaid to be of a yellowiſh, reddiſh, or variegated colour, and to be found mixed with the calx of biſmuth, incruſting other ores. Veltheim Grundriſs.

Mineralized by Sulphur.

6. It is chiefly found in *Sweden*, is of a bluiſh grey colour, lamellar texture, and teſſellar form like galena, but much heavier; it ſometimes preſents parallel ſtriæ like antimony, and its colour is variegated; it is ſaid to contain beſides biſmuth alſo cobalt and arſenic. 3 *Lin. von Gmelin*, 133. This ore is very fuſible, and the ſulphur moſtly ſeparates on ſcorification; it is ſoluble in nitrous acid, and is analyſed like the foregoing ores.

Mineralized by Sulphur with Iron.

7. This is ſaid to be of a lamellar cuneiform texture, and to be found in *Norway*.

8. In the dry way biſmuth is extracted from its ſtony ores by mixing 2 parts of the pulverized

pulverized ore with 1 of pounded glaſs, and 1 of calcined borax, melting the whole in a crucible lined with charcoal.

CHAP. XIII.

Cobalt.

1. Cobalt, or regulus of cobalt, as it is called by ſome, is of a bluiſh grey colour, very hard, brittle, and ſteel grained; its ſpecific gravity is about 7,700; its fuſibility is nearly as that of copper; it is difficultly calcined, and its calx is of a blue, ſo deep as to appear almoſt black; and this calx melted with borax, or potaſh and white ſiliceous ſand, gives a blue glaſs: this calx is not volatil; the regulus is eaſily ſoluble in ſpirit of nitre or aqua regia, and the colour of the ſolution is red, but difficultly in the vitriolic and ſcare at all in the marine acid; the calx is more eaſily diſſolved by theſe acids; it yields even to the acetous.

Species I.

Native.

2. This has not as yet been found; that which paſſes for ſuch is mineralized by arſenic.

Species II.

Mineralized by the aerial acid.

Black Ochre of Cobalt, Vitreous Ore of Cobalt, Kobalt mulm, Schlaken-Kobalt.

3. This appears either in a looſe, powdery form, ſometimes as fine as lamp black, either grey or blackiſh, and called cobalt ochre, or in black indurated ſcoriform maſſes, called *Schlaken Kobalt*, or vitreous cobaltic ore: they are both commonly free from ſulphur and arſenic, and when there are any, they are only mechanically mixed with this ore; ſome ſmall proportion of copper and iron is alſo ſometimes found in it; it is frequently imbodied in ſtones or ſands of a black colour; talc, chalk and gypſum impregnated with it have been called by the ſame name, and by ſome *Spiegel Cobalt*; it is alſo contained in ſome green and blue earths as already mentioned, p. 78, and 79.

4. To analyſe this ore let it be diſſolved in the nitrous acid; a plate of copper dipped in the ſolution will diſcover and precipitate the ſilver, if any, and a plate of iron will diſcover and precipitate copper, if the ſolution contains any; but it ſhould ſpeedily be withdrawn leſt the cobalt alſo ſhould be precipitated;

tated; then the whole ſhould be precipitated by a fixed alkali, and dephlogiſticated by abſtraction of the nitrous acid and calcination; if the calx be then digeſted in diſtilled vinegar, the cobaltic part alone will be taken up, and may be precipitated by mild mineral alkali. 160 gr. of this precipitate denote 100 of cobalt in its metallic ſtate.

Species III.

Mineralized by the Vitriolic or Arſenical Acids.

Red Cobalt Ochre, Kobalt bluth, Fleurs de Cobalt.

5. This alſo is found either *looſe* and pure, or mixed with chalk or gypſum, or *indurated* and cryſtalized in tetrahædral cryſtals, or in a ſtalactitical form; it melts eaſily, and then becomes blue; it frequently inveſts other cobaltic ores, and is found ſometimes in ſtones, or ſand. Mr. *Bergman* has ſhewn that the arſenical acid, and not the calx of arſenic, enters into this combination, for cobalt is never red, but when united to an acid.

6. To analyſe this ore, Mr. *Bergman* adviſes to diſſolve it in water, acidulated with ſome acid (ſuppoſe the nitrous) and then to precipitate the cobaltic part with mild mineral alkali; the liquor will contain cubic

nitre and Glauber's ſalt, if the vitriolic acid be the mineralizer, or arſenicated ſoda, if the arſenical acid exiſts in the compound.

Species IV.

Mineralized by Arſenic, with ſcarce any Iron.

Grey Cobalt Ore. Stahl derben Kobalt, *Glantz Cobalt.*

7. Solid, heavy, compact, ſometimes of a dull, and ſometimes of a bright appearance, frequently cryſtalized in a teſſelar, ſometimes in a dendritical form, and generally ſo hard as to give fire with ſteel.

8. It is analyſed by ſolution in aqua regia, or nitrous acid and evaporation to dryneſs; the reſiduum treated with the acetous acid will yield to it the cobaltic part; the arſenic ſhould at firſt be precipitated by the addition of water.

9. Or elſe this ore may firſt be roaſted to expell the arſenic, and then treated with nitrous acid, the cobalt will be diſſolved with very little of the iron, then by boiling the ſolution moſt of the iron will be precipitated, and by adding a fixed alkali, the remainder of the iron will firſt be precipitated yellowiſh, and afterwards the cobalt reddiſh. *Mem. Berl.* 1779.

1779. p. 16. So alſo the *Pruſſian* alkali will firſt precipitate the iron blue, and afterwards the cobalt reddiſh, (*ibid.*) or rather grey.

SPECIES V.

Mineralized by Sulphur and Arſenic with Iron.

White arſenicated Cobalt Ore, Kobalt Glantz.

10. This bears a great reſemblance to the laſt, but is ſofter, for it never ſtrikes fire with ſteel, and ſometimes it is ſo ſoft that it may be ſcraped with a knife; it moſtly appears under ſome polygon form; the moſt ſhining ſorts of this, and of the former Species, have been called *Cobalt Glantz.*

It is analyſable like the former Species; the ſulphur may be caught on the filter.

SPECIES VI.

Mineralized by a ſmall Proportion of Sulphur, with a notable Proportion of Iron without any Arſenic.

White unarſenicated Cobalt Ore.

11. It is ſometimes found in large maſſes, and ſometimes in grains cryſtalized, of a dull white colour, and frequently bears the ap-

 pearance

pearance of miſpickel; it becomes black, and not red by calcination, which diſtinguiſhes it from pyrites; it contains ſo little ſulphur, that none can be extracted from it; when diſſolved in aqua regia, its ſolution is yellow while cold, but greeniſh when boiling, which viciſſitude of colour is peculiar to marine cobalt; it contains much more iron than it does cobalt.

12. In the dry way cobaltic ores, after freeing them from their matrix by waſhing, and from ſulphur and arſenic by roaſting, are reduced by melting them with three parts black flux in a lined and covered crucible, in a ſmith's forge; the beſt ores contain from 60 to 80 per cent. of regulus, the worſt under 25 per cent. Smalt is reducible in the ſame manner.

13. To eſſay the tinging power of cobaltic ores, the roaſted ore is melted with three times its weight of pot-aſh, and five times its weight of pounded glaſs or flint, putting in the pot-aſh firſt, then the glaſs or flint, and over all the ore. *Scheff.* 3 2.

14. If any biſmuth be contained in the cobalt ore, it will not mix with the regulus of cobalt, unleſs nickel alſo be contained in it, but will ſimply adhere to it, and may be ſeparated

parated by the hammer, or by melting it, as it melts much eaſier than cobalt; when cobalt is by means of nickel united to biſmuth, the compound is called *Speiſs*; ſo alſo is a compound of cobalt, nickel, biſmuth, ſulphur and arſenic.

15. In general, cobaltic ores are known by their property of affording ſympathetic ink when digeſted in aqua regia, after the biſmuth is precipitated by the addition of water.

CHAP. XIV.

Nickel.

1. Nickel is a reddiſh white ſemi-metal of great hardneſs, ſo that it can ſcarce be filed, and of an equable texture; its ſpecific gravity varies according to its purity from 7,421 to 9,000, the pureſt being the heavieſt; when very pure it is in ſome degree malleable, and always magnetic, and hence it is deemed to retain iron. The fuſibility of the common regulus is nearly as that of copper: it calcines more difficultly than cobalt; its calx is green, and riſes in a tuberoſe fungous form; it is difficultly ſoluble in the vitriolic or marine acid, but eaſily in the nitrous; all theſe ſolutions are green, and volatil alkali turns them

 blue,

blue, but iron diſcovers no copper in them, as it does in every combination of copper, ſulphur, iron, arſenic, and cobalt. Hence nickel muſt be deemed a diſtinct ſemi-metal: beſides, Mr. *Bergman* has ſhewn that ſulphur, arſenic and cobalt may be perfectly ſeparated from it, though perhaps iron cannot; but it ſeems to me very probable that nickel itſelf may be magnetic: the pureſt regulus is much more difficultly calcined or melted.

Species I.

Native.

2. This is mentioned by Mr. *Rinman* to have been lately found in a mine of cobalt in *Heſſe*; it is very heavy, and of a liver colour, that is, dark red; when pulverized and roaſted under a muffle, it forms green excreſcences, and ſmokes, but its ſmoke has no particular ſmell, and no ſublimate, whether ſulphureous or arſenical, can be caught; it is ſoluble in acids, and the ſolution is green; but a poliſhed iron plate diſcovers no copper.

Species II.

Mineralized by the aerial Acid.

Native Calx of Nickel.

3. It is found in the form of a green calx, mixed

mixed with calx of iron, ſcattered over the ore of kupfernickel; alſo in ſome green clays. *Cronſt.* §. 255.

SPECIES III.

Mineralized by the Vitriolic Acid.

Vitriol of Nickel.

4. Already mentioned in the 2d Part, p. 195.

SPECIES IV.

Mineralized by Sulphur and Arſenic, with Cobalt and Iron.

Kupfernickel.

5. This is of a reddiſh yellow bright colour; its texture either uniform, granular or ſcaly, bright in its fracture, very heavy, and generally covered with a greeniſh effloreſcence; by calcination it loſes much of its ſulphur, and becomes green, forming fungous ramifications.

6. Its analyſis in the moiſt way is as yet very imperfect; by ſolution in the nitrous acid it is freed from its ſulphur, and by adding water to the ſolution, biſmuth, if any, may be precipitated, as may ſilver if con-

 tained

tained in it by the marine acid, and copper when any by iron. To ſeparate cobalt from nickel when the cobalt is in conſiderable quantity, Mr. *Gerhard* adviſes to drop a ſaturate ſolution of the roaſted ore in nitrous acid, into liquid volatil alkali: the cobaltic part is inſtantly re-diſſolved, and aſſumes a garnet colour; when filtered a grey powder remains on the filter, which is the nickel: the cobalt may be precipitated from the volatil alkali by any acid. *Mem. Berlin*, 1779, p. 17 and 18. cobalt may alſo, in ſome meaſure, be ſeparated from nickel, by melting it with three times its weight of liver of ſulphur; the cobalt will be taken up, and may be ſeparated by lixiviation. 2 *Bergm.* 244.

7. In the dry way a regulus is obtained from the ores of nickel by long continued torrefaction, which expels much of the ſulphur and arſenic, and then melting the green calx thus obtained, with twice or thrice its weight of black flux in an open crucible covered with common ſalt by the ſtrongeſt fire of a ſmith's forge, a regulus is found, which amounts to from 30 to 50 per cent. of the weight of the green powder: this regulus ſtill contains ſulphur, arſenic, cobalt and iron; its further depuration is very laborious, and may be ſeen in the ſecond volume of Mr. *Bergman*'s works.

8. It

8. It is highly probable that nickel exiſts in ſome ſpecies of roof ſlates, and in hornſtones, whoſe ſolution in ſpirit of nitre is of a green colour.

CHAP. XV.

Regulus of Mangane∫e.

1. This ſemi-metal was for the firſt time clearly deſcribed, and its properties admirably inveſtigated and explained by Mr. *Scheele* in the *Memoirs of Stockholm*, for the year 1774. It was afterwards exhibited in its metallic form by Mr. *Gahn*, and its properties in that ſtate, deſcribed by Mr. *Bergman* in the ſecond volume of his works; ſince that publication it has frequently been produced in *France* by Meſſrs. *Morveau* and *Lapeirouſe*, and lately here by Mr. *Woulfe*.

2. This regulus is of a duſky white colour, an irregular and uneven ſurface, ariſing from its imperfect fuſion; in its fracture it is bright and ſhining, but ſoon tarniſhes by expoſure to the air; it is harder than iron, leſs fuſible, and very brittle; its ſpecific gravity is 6,850. When pulverized it is always magnetic, though larger pieces be not ſo; if it be expoſed to the air, particularly in moiſt weather, it ſoon crumbles into a blackiſh brown powder,

der, which is ſomething heavier than the regulus. It is ſoluble in acids, but moſt readily in the nitrous, and its ſolutions are moſtly colourleſs, but that in the nitrous is generally browniſh from a ſlight taint of iron, but there is always a ſpungy reſiduum of the nature of plumbago, left undiſſolved. Theſe ſolutions give a white precipitate with aerated alkalis, which precipitate when heated grows black.

3. The regulus is obtained by mixing the calx or ore of Manganeſe with pitch, making it into a ball, and putting it into a crucible lined with powdered charcoal $\frac{1}{10}$ of an inch thick on the ſides, and $\frac{1}{4}$ of an inch at bottom, then filling the empty ſpace with powdered charcoal, covering the crucible with another inverted and luted on, and expoſing it to the ſtrongeſt heat of a forge for an hour or more.

SPECIES I.

Native.

4. This has not as yet been found, nor can it be expected, (unleſs perhaps alloyed in native iron) as manganeſe loſes the proportion of phlogiſton neceſſary to its metallic form, more readily than any other metallic ſubſtance.

Species II.

Mineralized by the Aerial Acid.

Native Calces of Manganeſe.

5. The aerial acid is the only mineralizer of manganeſe in a dry ſtate, yet known; and according to the different degrees of phlogiſtication of the manganeſe, it forms with it calces of different colours and different properties, to underſtand which it is neceſſary to remark, that when manganeſe is as much phlogiſticated as it can be, without being in a reguline ſtate, it forms a *white* calx, which contains a large portion of fixed air (about 40 per cent.) which enables it to retain phlogiſton, as the compound of acid and calx, attracts phlogiſton more ſtrongly than either does when ſingle; in proportion to its dephlogiſtication, and by union with other ſubſtances, its colour is either *blue*, *green*, *yellow*, *red*, *brown* or *black*; *blue*, is that which it acquires from the proportion of phlogiſton, which it is enabled to retain by reaſon of its union with fixed alkalis; *green* ariſes from a mixture of the blue with the yellow calx of iron; *yellow* always ariſes from the prevalence of the calx of iron; *red*, from a ſlight phlogiſtication of the calx of manganeſe; *black*, from its thorough dephlogiſtication.

cation. Yet if the black calx be long roaſted, it becomes *green*, which I think ariſes from the expulſion of fixed air, which leaves its phlogiſton with the manganeſe, and thus produces a *blue*, which mixed with the yellow calx of iron, gives a *green*; *brown* ariſes from a mixture of the red and black calces of manganeſe. Theſe obſervations I have extracted from Mr. *Scheele's* incomparable diſſertation.

6. All theſe calces, of whatever colour they may be, communicate a *garnet* colour to glaſs of borax, when treated with a blow pipe, for being melted into a round globule, the ſurrounding atmoſphere dephlogiſticates them ſufficiently to make them aſſume this colour.

7. Hence we may diſtinguiſh 3 principal varieties of the native calx of manganeſe, the white, the red, and the black.

I. Variety.

White Ore of Manganeſe.

8. This contains but a very ſmall proportion of iron; it has been found by Mr. *Rinman* both in ſmall white cryſtals, and in round maſſes in the cavities of quartz and adhering to glanzblend, rather leſs hard than limeſtone,

ſtone, of a ſparry texture, and ſcarcely magnetic even after roaſting, ſoluble with effervеſcence in nitrous acid, and affording a colourleſs ſolution, which ſolution, with mild alkalis, gave a white precipitate, and the precipitate, when heated, preſently grew black; a ſure criterion of manganeſe. *Mem. Stock.* 1765.

9. Mr. *Lapeirouſe* found this white ore in the form of a ſpungy efflореſcence, vegetating on the ſurface of ſome iron ores, particularly hæmatites.

10. It has been ſeen alſo by Mr. *Rinman* in the form of a calcareous ſpar, *of the colour of roſin*, and ſomewhat ſhining, in ſome places covered over with a ſooty powder, and in thin pieces ſemi-tranſparent at the edges, and not hard enough to ſtrike fire with ſteel; nitrous acid diſſolves it almoſt intirely, with mild alkalis the ſolution gives a white precipitate, which blackens when heated. It conſiſts of *manganeſe imbodied in zeolyte*, it melts *per ſe* with the blow pipe into a whitiſh grey porous ſlag, and with the addition of calcined borax gives a garnet coloured glaſs.

11. Many of white ſparry iron ores may alſo be claſſed among the ores of manga-

neſe,

nefe, as they contain more of it than of iron.

II. Variety.

Red Ore of Manganefe.

12. It contains lefs fixed air, and is accompanied with more iron than the former variety, and alfo with calcareous or ponderous earth and filex. It is found either loofe and femi-indurated in a matrix of calcareous fpar, or talky fhiftus, or on hæmetites and other iron ores, or in heavy hard maffes of a lamellar, radiated, or equable texture, or cryftalized in pyramids, rhomboids, or fhort bright brittle needles. 15. *Roz.* 69.

III. Variety.

Black and Brown Ore of Manganefe.

13. I place thefe together, as they differ but little; they are found either cryftalized in the fame form as the red ore, or in folid maffes, fome of which have a metallic appearance, others are dull, earthy, and mixed or embodied with quartz, or in a loofe earthy form; their fpecific gravity is about 4,000 both, particularly the brown and the red are foluble in fome meafure by digeftion in oil of vitriol, and the folution is at firft reddifh, but afterwards

afterwards becomes colourlefs, unlefs they contain a large proportion of iron. But the dephlogifticated nitrous acid does not act on them except fugar be added, and then this acid, as well as the concentrated vitriolic, operates a colourlefs folution, which with mild alkalis, gives a white precipitate of the fame nature as the firft variety; they contain more iron and lefs fixed air than the former varieties.

14. *Perigord Stone* belongs to this variety, it is of a dark grey colour like bafaltes or trapp, may be fcraped with a knife, yet is difficultly broken; when calcined it becomes of a reddifh brown colour and harder, but not magnetic. Its fpecific gravity is confiderable, it does not melt *per fe*, but with borax it affords an amethyftine glafs; nitrous acid fcarcely acts on it without the addition of fugar, this ftone feems alfo to contain argill, and fome portion of iron.

15. One of the moft remarkable ores of manganefe is that called *black wad*; it is of a dark brown colour, partly in powder and partly indurated, and brittle. If half a pound of this be dried before a fire, and afterwards fuffered to cool for about an hour, and then two ounces of lintfeed oil be gradually poured on it, mixing them loofely like barm with flour,

flour; little clots will be formed, and in something more than half an hour the whole will gradually grow hot, and at laſt burſt into a flame, as I have ſeen ſeveral times at the houſe of Sir *Joſeph Banks*. The temperature of the room where the experiment was made was about 50: the heat this ore was expoſed to while drying might be about 130.

16. According to Mr. *Wedgewood*'s analyſis 100 parts of black wad contain 43 of mangaueſe, 43 of iron, 4,5 of lead, and 5 of mica.

17. To analyſe the abovementioned ores, they ſhould be firſt roaſted to dephlogiſticate, the calx of manganeſe, and iron if any, then treated with dephlogiſticated nitrous acid to diſſolve the earths; the reſiduum ſhould then be treated with nitrous acid and ſugar, by which means a colourleſs ſolution of manganeſe will be obtained, which being precipitated by aerated mineral alkali, will give a precipitate 100 gr. of which are equivalent to 100 of regulus of manganeſe.

18. Many ſpecies of iron ore contain manganeſe. To diſcover it, let the iron be diſſolved in ſome acid, and precipitated by the *Pruſſian* alkali; let the ſolution be poured off, and the precipitate digeſted in pure water;

water; the *Prussian* manganese will be dissolved, and the *Prussian* iron remain undissolved. See also Chap. 5. N° 41 and 53.

Manganese in Vegetables.

19. "Manganese seems to be contained "in the ashes of most vegetables, and to it "the blue or greenish colour of calcined vegetable alkali is owing. These colours "are generally attributed to the phlogiston "of the alkali; but if so, they should not "be found in fixed nitre, as the nitrous acid "should carry off during its decomposition "all the phlogiston; yet this alkali is always "greenish, so that the colour seems to arise "from the ashes of the charcoal with which "the nitre was decomposed. If 3 parts of "the alkali of tartar, 1 of sifted ashes, and "$\frac{1}{8}$ of nitre be melted together, they form "a dark green mass, which being dissolved "in water affords a beautiful green solution, "and this being filtered, on the addition of a "few drops of oil of vitriol, becomes red, "and after a few days a brown powder is "deposited, which has the properties of "manganese." *Scheele* 56 *Mem. Stock.* 1774, p. 189. The ashes of serpyllum contain very little of it, those of trees contain most. *Ibid.* 180.

CHAP. XVI.

Siderite.

1. The firſt diſtinct mention I find made of this ſubſtance is in the *Mineralogy* of Mr. *Monnet*, p. 384, printed in 1779; but the merit of diſcovering its nature is undoubtedly due to Mr. *Meyer* of *Stetin*, who, not contenting himſelf with vague generalities, developed its principal properties by a ſeries of ingenious and well connected experiments publiſhed among the Memoirs of the philoſophical ſociety of *Berlin* for the year 1781 and 1782; ſome few of which he alſo mentioned in the Memoirs of the preceding year. Mr. *Bergman*, ignorant of what Mr. *Meyer* had done, arrived at the ſame concluſions nearly at the ſame time, as may be ſeen in the 3d volume of his works, and diſcovered ſome additional properties of this new ſemi-metallic ſubſtance. From theſe ſources I have extracted the following account of it.

2. Siderite is principally found in iron of the firſt fuſion or caſt iron, and in the ores of coldſhort iron. The manner of its extraction has been already mentioned, Chap. 5. No. 46. A pound of caſt iron ſometimes affords about

about 12 drachms of this calx, whose natural colour is white, but it is generally tinged brown or yellow from a mixture of the calx of iron. Mr. *Bergman* purifies it by repeatedly abstracting the nitrous acid over it, which dephlogisticates the iron, and leaves the calx of siderite soluble in the mineral acids, but not in the acetous.

3. The solutions of it in the vitriolic and marine acids crystalize, though very difficultly; it rather tends to form a jelly, particularly if there be an excess of acid; the solution in the nitrous is reddish, and in the marine yellowish; all are slowly precipitable by water.

4. This calx is also in some measure soluble in water, but 1 part of it requires 1500 of boiling water for its solution.

5. Alkalis, both fixed and volatil, have some action on it, and acquire a brown tinge from it.

6. In the dry way it melts *per se* on charcoal, and is not volatil; it gives glass a green colour, except it meets phlogiston, and then the colour is brown.

7. It is reduced to a regulus by melting it

with half its weight of borax in a crucible lined to the thickneſs of $\frac{1}{10}$ of an inch with a mixture of charcoal and a little clay, and expoſing it to the fire of a ſmith's forge for three quarters of an hour.

8. The regulus is of a ſteel grey colour, not ſo hard as cobalt, exceeding brittle, not magnetic in ſmall pieces, though ſlightly ſo when powdered. Its texture is granular; its ſpecific gravity about 6,710.

9. Its fuſibility is nearly as that of copper, and it ſeems to contain ſomething more phlogiſton than iron does; it is not volatil when heated.

10. It is very difficultly ſoluble in any acid, and requires the aſſiſtance of heat; after ebullition for ſome days the nitrous acid out of 5 grains diſſolved only 4, aqua regia 4,2, dilute vitriolic acid 3,5, and the marine 3. Infuſion of galls turns theſe ſolutions black; the *Pruſſian* alkali gives a dark blue precipitate, and common alkalis a white precipitate.

11. It precipitates gold, ſilver and copper very ſlowly from their ſolutions, and in their metallic form; but lead from nitrous acid in the form of a calx; it does not precipitate mercury from the nitrous acid.

12. It

12. It is itſelf precipitated from the nitrous acid in the form of a brown calx by zinc and iron. Copper ſeems to precipitate only a little dephlogiſticated iron from it, to which a little of the white calx is united; lead alſo produces the ſame effect.

13. It does not detonate with nitre, though it alkalizes it, and is dephlogiſticated by it.

14. It does not unite with ſulphur.

15. It ſublimes with ſal ammoniac, and takes a yellow colour.

16. It does not amalgamate with mercury, but when in fuſion it unites with iron, copper, or cobalt, but not with any other metal, except perhaps nickel, which has not been tried; it converts bar iron into the ſtate of crude or caſt iron, and when in a ſmaller proportion renders it *coldſhort.*

CHAP. XXII.

Molybdena. Molybdena membranacea Cronſt. 154. *Waſſerbley of the Germans.*

1. It reſembles plumbago, but its laminæ are larger, brighter, and when thin ſlightly flexible; it is of a lead colour, and does not

 ſtrike

ſtrike fire with ſteel; its ſpecific gravity is 4,569.

2. In an open fire it is almoſt intirely volatil and infuſible. Microcoſmic ſalt or borax ſcarcely affect it, but it is acted upon with much efferveſcence by mineral alkali, and with it forms a reddiſh maſs, which ſmells of ſulphur.

3. It is affected by no acid, but the nitrous and arſenical, both require the aſſiſtance of heat; the latter is converted into orpiment.

4. Mr. *Scheele* has found it to conſiſt of an acid of a peculiar nature united to ſulphur; a ſmall proportion of iron is commonly found in it; but this ſeems merely fortuitous; 100 parts of it contain about 45 of acid, and 55 of ſulphur.

5. It is decompoſed either by detonation with nitre, or by ſolution in nitrous acid: this latter method is the readieſt: for this purpoſe it is to be 5 times diſtilled, each time with 4 times its weight of ſpirit of nitre; a white calx at laſt remains, which is the molybdenous acid.

6. This acid is ſoluble in 570 times its weight

weight of water in the temperature of 60; the ſolution reddens that of litmus, precipitates ſulphur from the ſolution of liver of ſulphur, &c. the ſpecific gravity of the dry acid is 3,460. 3 *Bergm.*, 127.

7. This acid is precipitable from its ſolution in water by the *Pruſſian* alkali, and alſo by tincture of galls the precipitate is reddiſh brown.

8. If this acid be diſtilled with three times its weight of ſulphur, it re-produces molybdena.

9. The ſolution of this acid in water unites to fixed alkalis, and forms cryſtalizable ſalts; ſo it does with calcareous earth, magneſia, and argill: theſe laſt combinations are difficultly ſoluble; it acts alſo on the baſe metals, and with them aſſumes a bluiſh colour.

10. This ſolution precipitates ſilver, mercury, or lead from the nitrous acid, and lead from the marine, but not mercury.

It alſo precipitates barytes from the nitrous and marine acids, but no other earth. Molybdenous baroſelenite is ſoluble in cold water.

11. This acid is itſelf ſoluble in the vitriolic acid with the aſſiſtance of heat, and the ſolution is blue when cold, though colourleſs while hot; it is alſo ſoluble in the marine acid, but not in the nitrous.

12. Molybdenous tartar and ammoniac precipitate all metals from their ſolutions by a double affinity. Gold, ſublimate corroſive, zinc and mangane ſe, are precipitated *white*; iron or tin from the marine acid *brown*; cobalt *red*; copper *blue*.

13. Alum and calcareous earth white. *Scheele Mem. Stock*, 1778.

14. This acid has been lately reduced by Mr. *Hielm*, but the properties of the regulus thus obtained are not yet publiſhed.

CHAP. XVIII.

Of the Tungſtenic Acid.

Though this acid, and the manner of obtaining it have been already mentioned, p. 38, yet as it is of a metallic nature, a few of its diſtinguiſhing properties may properly be inſerted here.

1. Its ſolution in water reddens that of litmus;

litmus; with alkalis it forms cryſtalizable ſalts; with barytes calcareous earth, and magneſia inſoluble compounds.

2. This ſolution is precipitated white by the *Pruſſian* alkali, and the precipitate is ſoluble in water.

3. It precipitates the ſolutions of vitriols of iron, zinc, copper, and the nitrous ſolutions of ſilver, mercury and lead, and that of lead in marine acid; all theſe precipitates are white: the ſolution of tin in marine acid is precipitated blue, but the ſolutions of gold and ſublimate corroſive are not altered by it.

4. The ſolutions of chalk or alum are not altered by it; but that of barytes in the acetous acid is precipitated, and the precipitate is inſoluble.

CHAP. XIX.

Saturnite.

The ſubſtance to which I ventured to give this name, is ſaid by Mr. *Monnet*, to be found in the lead mines of *Poullaoven* in *Brittany*, and is ſeparated from the lead ore during its torrefaction. According to him it reſembles lead in its colour and ſpecific gravity,

gravity, is ſoluble in the ſame acids, and with the ſame phænomena; but it is much more fuſible, very brittle, eaſily ſcorified and volatilized, and refuſes to mix with lead when in fuſion. It were to be wiſhed it was better examined.

CHAP. XX.

Reflexions on the nature of Cabalt, Nickel, and Manganeſe.

1. The principal reaſon why any ſimple ſubſtances are reckoned ſpecifically different from each other, is their manifeſting properties permanently different in the ſame circumſtances, and every ſubſtance muſt be deemed ſimple, until it can be reſolved into different principles, or formed out of them. Every other indication is at beſt a ſurmiſe grounded on mere poſſibility, but deſtitute of probability, and therefore inadmiſſable in any exact ſcientifical ſyſtem; upon this foundation moſt chymiſts and mineralogiſts have admitted the abovementioned ſubſtances to a diſtinct rank among ſemi-metals. Yet as ſome others deſervedly of great note, namely, Mr. *Pabſt*, Mr. *Monnet*, and *Romé de Liſle*, have aſſerted, that all, or ſome or other of theſe ſemi-metals, are either modifications of iron, or compounds of ſome ſort; I preſume it will not be amiſs before I conclude this treatiſe, to ſtate

ſtate the reaſons they have alledged, and juſtify the opinion I have followed.

Of Cobalt.

2. With regard to cobalt, ſome have thought it to be nothing elſe but a compound of iron and arſenic, aſſerting that ſuch a compound would communicate a blue colour to glaſs, but this pretenſion has been fully refuted by the experiments of Mr. *Brandt. Mem. Sued.* p. 46 and 47. and thoſe of Mr. *Monnet. Diſſ. Des. Mett.* p. 279.

3. Others have thought that the tinging quality is produced in cobalt, merely by its union with arſenic, becauſe it ſometimes happens, that cobalt will not tinge, unleſs arſenic be added to it. But the true reaſon of this phænomenon is, that cobalt will not tinge unleſs it is dephlogiſticated, nor even then unleſs it melts, and it ſometimes happens that cobalt is too much dephlogiſticated, and then it will not melt in the uſual heat, without the addition of arſenic, which ſerves as a flux to it; for that arſenic is not otherwiſe eſſential to its tinging property is evident from this, that ſome cobalt ores, which tinge admirably well, are yet abſolutely free from arſenic, ſuch as the vitreous ore, *Sp. 2d.*

4. It is true, that in ſome circumſtances glaſs may be tinged blue by iron, as Mr. *Gmelin* has learnedly ſhewn in the 5th part of Mr. *Crell's Chymical Journal*; but this iron is not transformed into cobalt; for if that glaſs be digeſted in aqua regia, the ſolution will not form a ſympathetic ink; but, on the contrary, will manifeſt every property of iron; whereas glaſs tinged blue by cobalt will, when digeſted with aqua regia, afford ſympathetic ink, and manifeſt the other diſtinctive characters of cobalt.

Nickel.

5. Mr. *Monnet* thinks that cobalt and nickel are one and the ſame metal, which when united to iron, exhibits the properties of, and is called *cobalt*, but when free from iron, is called *nickel*; ſo that nickel is the ſimple ſubſtance, and cobalt the compound. The ſolutions of cobalt he adds are red, merely on account of the iron, otherwiſe they would be green like thoſe of nickel; the blue tinging matter he ſays is inherent in cobalt, but it cannot be developed without the addition of iron and arſenic. This opinion carries its own refutation with it, for common nickel always contains at leaſt as much iron as cobalt does, and yet conſtantly gives glaſs a reddiſh yellow colour, and if ever the addition of arſenic

arſenic makes it give a blue tinge to glaſs, it is becauſe it contains a portion of cobalt, which is not eaſily dephlogiſticated, but remains in a reguline ſtate, and while it remains in this ſtate, it can give no colour to glaſs, but the addition of arſenic dephlogiſticates this portion of cobalt, and thus enables it to unite to, and tinge glaſs, and this is ſo true, that the addition of nitre, which dephlogiſticates ſtill more powerfully than arſenic, produces the ſame effect, as Mr. *Bergman* has ſhewn in his elaborate diſſertation on Nickel, 2 *Nov. Act. Ups.* p. 243. ſo that arſenic is no way neceſſary; and moreover it is abſolutely falſe, that the addition of iron and arſenic will ever give nickel the properties of cobalt, as Mr. *Monnet* himſelf muſt well know. However, the reaſons he alledges to prove the identity of theſe ſemi-metals are,

6. 1°. That cobalt and nickel are ſoluble in the ſame acids, and acted on by theſe acids in the ſame manner, all the difference being that the ſolutions of cobalt are red, and thoſe of nickel green; a difference aſſuredly very great, and which no addition of iron and arſenic to nickel will alter, as it ſhould according to his ſyſtem; for let him combine iron and arſenic with nickel as he pleaſes, he will never make a ſubſtance whoſe ſolution in acids will be *red*, as that of cobalt is. But further, if

by

by *acids* he means the mineral acids and the acetous, then he may as well ſay that biſmuth is the ſame ſubſtance as cobalt and nickel, for it is acted upon by theſe acids in nearly the ſame manner, but if he means the long tribe of other acids, the aſſertion is not true, ſince the tartarous acid for inſtance does not act on nickel, whereas it does on cobalt.

7. 2ly. Becauſe though the ores of Nickel become *green* by calcination, and thoſe of cobalt, *blue*, yet if the calcination of the nickel be continued, its calx will become *brown*; but I do not ſee how this change to a reddiſh brown, approximates nickel to cobalt, any more than the green colour does, for it is equally different from the blue or chocolate colour of cobalt, and it appears from Mr. *Bergman's* experiments, that the green colour ariſes from a mixture of arſenic, for when nickel is thoroughly free from it, its calces are brown.

8. 3dly. Becauſe nickel long expoſed to the air, contains a green ruſt, as does cobalt But this appearance would as well indicate copper.

9. 4thly. Becauſe both nickel and cobalt unite with the ſame metals. He probably forgot

forgot that cobalt and bifmuth will not unite, nor will cobalt and filver, or cobalt and lead, whereas nickel will unite to any of them when well purified from cobalt, and with bif-muth, even without fuch purification.

10. 5thly. Becaufe according to *Cronfted* himfelf, nickel will give a blue colour to borax. But Mr. *Bergman* has fhewn, that when it is well purified from cobalt, it will give a hyacinthine, and not a blue tinge to borax. Mr. *Monnet* adds, that cobalt, melted with quartz and alkali, gives a *greenifh* brown glafs in fome circumftances, and quotes *Brandt*, but *Brandt* fays the colour was *reddifh* brown, and in effect this colour fhould be expected from the fpecies of cobaltic ore he examined, which was loaded with iron, and from the manner in which the experiment was conducted, the cobalt being too much dephlogifticated.

11. Laftly, he obferves that the cobalt is always magnetic; but it is to be obferved, that this magnetifm conftantly decreafes in proportion as it is freed from iron, and yet the cobalt remains in full poffeffion of all its properties, therefore its properties do not depend on the prefence of iron, and if it were perfectly free from iron (a ftate of purity to which Mr. *Monch* fays he has reduced it. 3 *Crell.* p. 164) it would not

not be in the leaſt magnetic; beſides this argument would ſubvert Mr. *Monnet*'s own opinion, for nickel is alſo always magnetic.

12. Mr. *Romé de Liſle* thinks that nickel conſiſts of iron, cobalt and copper intimately united:* although Mr. *Bergman* has demonſtrated that this opinion is deſtitute of any proof, either ſynthetic or analytic; for, in the firſt place, he mixed theſe ſubſtances in various proportions, but could produce nothing that reſembled nickel; and, in the 2d place, he ſhewed that copper is very ſeldom mixed with it, and when it is, may eaſily be ſeparated, and cobalt alſo may be ſeparated though more difficultly. But Mr. *Romé* looks on the blue colour which volatil alkalis produce in the ſolutions of nickel, as an evident ſign of its containing copper. To make this proof of any weight, we muſt aſſume this principle; *that two different metals cannot give the ſame colour to the ſame menſtruum*, which is evidently falſe, for gold and platina give the ſame colour to aqua regia, to ſay nothing of the various metals, whoſe ſolutions in nitrous acid are colourleſs. The only conſequence ſtrictly deducible from the colour of a menſtruum is purely negative; namely, *that it does not*

* Chryſtilographie, p. 91.

ſingly

singly contain any substance, which is known to communicate a different colour to that menstruum in the same circumstances; for there is scarce any one property of any substance that may not be communicable to some other substance, as it is only the aggregate of all their properties that fully distinguishes substances from each other.

13. He further adds, that nickel cannot be looked upon as a distinct semi-metal, because it cannot be thoroughly purified from iron. What stress should be laid on this argument, we shall presently consider in treating of manganese; but in the mean time we may observe that it is far from being clear that nickel can never be purified from iron; for the only ground of this suspicion is, that the purest nickel is magnetic; but this must be deemed insufficient, unless it be taken for granted that magnetism is a property inherent in iron only, and incommunicable to all other possible metallic substances, as we know it is to those that are already known; a position which seems to me fully contradicted in the case of nickel; for when it is purified as much as possible from iron, it becomes *more* instead of *less* magnetic, and even acquires what iron does not, the properties of a magnet. What hinders us then from allowing magnetism, like the property of giv-

ing a blue colour to alkalis, to be common to thoſe different metallic ſubſtances in which we find it?

Manganeſe.

According to Mr. *Romé* this ſemi-metal is a mixture of iron, zinc and cobalt: that it contains iron is not denied; but it is aſſerted, that beſides iron it contains a peculiar ſemi-metal, whoſe properties are independent of the preſence of iron, ſince they are abſolutely different from thoſe of iron, and every alloy of iron with any other known metallic ſubſtance, and are ſo much the more apparent, as the portion of iron it contains is diminiſhed. Nevertheleſs, Mr. *Romé* objects that the regulus of manganeſe can never be totally freed from iron, and that all the experiments hitherto made upon it being made on a mixed ſemi-metal, the properties diſcovered by theſe experiments ſhould be deemed thoſe of a mixed, and not thoſe of a ſimple ſubſtance. But the fallacy of this reaſoning will readily appear, if it be conſidered that, though until lately, platina could not be obtained perfectly free from iron; yet the moſt judicious chymiſts in Europe, *Lewis*, *Margraaf*, *Scheffer*, *Macquer* and *Baumé*, were of opinion that it was a peculiar diſtinct metallic ſubſtance; and at this day regulus of antimony and tin are never abſolutely free from

from iron, yet no one dreams of attributing their peculiar properties to an alloy of iron, and any other metal; and indeed if this manner of reasoning were of any weight, no properties could be attributed to any simple substance; for what substance can be procured absolutely pure? When was water rigorously pure ever found or procured, or gold of 24 carats? Unless therefore we can produce by art a compound similar to that which we presume to be a mixture, or shew some good reason why such a compound cannot be artificially produced, or unless we can decompose such substance, and thereby destroy its peculiar properties, or at least alter them by the substraction of any one of its supposed constituent parts, we must look upon the supposition that such substance is essentially a *compound*, as groundless relatively to the present state of our knowledge, on which alone, and not on mere possibilities, we can rationally found any assertion. The word *modification* has been strangely abused on this occasion. Cobalt, nickel and manganese, have been said to be only modifications of iron; but as long as it is not known wherein that modification consists, this word presents no idea whatsoever, and any other insignificant word may as well be used. If it be said that it denotes *iron with the addition of some unknown substance*, then it would follow at

 least,

leaſt, that by diminiſhing the proportion of iron, the ſpecific properties of the compound would be altered, which is not true with reſpect to theſe ſemi-metals, for the freer they are from iron, the more perfectly they manifeſt their peculiar properties; ſo that in every ſenſe this aſſertion is either falſe or unintelligible.

With reſpect to zinc and cobalt, there is not the leaſt foundation for ſuſpecting, much leſs affirming, their exiſtence in regulus of mangane ſe, as they are never found even in the ore of mangane ſe, except fortuitouſly; but, on the contrary, this ore is moſt frequently found without a particle of either; nor does the regulus ſhew any property that approximates it more to them than to other metallic ſubſtances, but, on the contrary, many that belong to no other, nor to any compound of any other metallic ſubſtances.

APPENDIX III.

Geological Obſervations.

Mountains.

ELEVATIONS, conſiſting chiefly of clay, ſand or gravel, are called *Hills*, thoſe that conſiſt chiefly of ſtone are by mineralogiſts called *Mountains*. As they are the chief repoſitories of minerals, and particularly of metallic ores, I ſhall here relate the moſt intereſting obſervations relative to them that have occurred to me, or that have been made by others.

Mountains may be conſidered either with a view to their antiquity and origin, their height, or their ſtructure.

Of the Antiquity and Origin of Mountains.

In this point of view mountains are divided into *primæval*, that is, of equal date with the formation of the globe, and ſecondary, or *alluvial*; ſome add even *tertiary*; but this diſtinction I think ſuperfluous.

Among the primæval, thoſe that conſiſt of granite hold the firſt place. The higheſt mountains, and moſt extenſive ridges in every

 part

part of the globe, are granitical. Thus the *Alps* and *Pyrenees* are the loftieſt in *Europe*, and particularly ſuch of them as conſiſt of granite, the *Altaiſchan*, *Uralian* and *Caucaſus* in *Aſia*, and the *Andes* in *America*. From them the greateſt rivers derive their origin. The higheſt of them never contain metallic ores, but ſome of the lower contain veins of copper or tin, as thoſe of *Saxony*, *Sileſia* and *Cornwall*. The granitic ſtones next the ore always abound in mica; petrefactions are never found in them.

Many of the granite mountains of *Aſia* and *America* form large plat-forms at about half their height, from which ſeveral lofty ſpires ariſe. No ſuch plat-forms have been obſerved in the *Alps* or *Pyrenees*.

That the formation of theſe mountains preceded that of vegetables and animals is juſtly inferred from their containing no organic remains either in the form of petrifaction or impreſſion, from their bulk, extenſion and connection, which ſeem too conſiderable to be aſcribed to ſubſequent cauſes, and from their uſe and neceſſity for the production of rivers, without which it is hard to ſuppoſe that the world had exiſted at any period ſince the creation of animals. Moſt naturaliſts are at preſent agreed that granites

were

were formed by cryſtallization. This operation probably took place after the formation of the atmoſphere, (which in the hiſtory of the creation is called the firmament) and the gradual excavation of the bed of the ocean; ſoon after which, it is ſaid, that by the command of God (that is, by virtue of the laws of nature which he eſtabliſhed) *the dry land appeared*; for by means of the evaporation of part of the waters into the atmoſphere, and the gradual retreat of the remainder, the various ſpecies of earths before diſſolved or diffuſed through this mighty maſs, were diſpoſed to coaleſce, and among theſe the *ſiliceous* muſt have been the firſt, as they are the leaſt ſoluble: but as they have an affinity to other earths with which they were mixed, ſome of theſe muſt alſo have united with them in various proportions, and thus have formed in diſtinct maſſes the felt ſpar, ſhoerl and mica, which compoſe the granite. Calcareous earth enters very ſparingly into the compoſition of this ſtone; but as it is found in ſhoerl, which is frequently a component part of granite, it follows that it muſt be one of the primitive earths, and not entirely derived from marine exuviæ as many imagine. Quartz can never be ſuppoſed to be a product of fire, for in a very low heat it burſts, cracks, and loſes its tranſparency, and in the higheſt we can produce, it is infuſible;

ſo that in every eſſential point it is totally unlike to glaſs to which ſome have compared it. As granite contains earths of every genus, we may conclude that all the ſimple earths are coeval with the creation. This obſervation does not preclude further reſearches into their compoſition; for though water undoubtedly dates from the creation, yet ſome late experiments ſhew it to be a compound: their ſimplicity may be only relative to the preſent ſtate of our knowledge.

Mountains, which conſiſt of *lime-ſtone* or *marble* of a granular or ſcaly texture, and not diſpoſed in ſtrata, ſeem alſo to have preceded the creation of animals, for no organic traces are found in them. Alſo thoſe that conſiſt of ſtones of the *argillaceous* genus, and of the 6th compound ſpecies of the ſiliceous genus, ſeem to be primæval, as they conta n no organic remains: theſe often conſiſt of parallel ſtrata of unequal thickneſs, and the lower are harder and leſs thick than the upper, whence the lower ſeem to have been firſt formed, and the upper latter. They are the principal ſeat of metallic ſubſtances, whoſe ores run acroſs the ſtrata in all directions; hence they are by the Germans called *Gang geburge*, and by the *French Montagnes à filons.* Coal is never found in them.

It

It is little to be doubted, but that ſubmarine volcanos preceded not only the creation of animals, but alſo the ſeparation of dry land from the waters, the Moſaic expreſſion, *Let there be Light*, ſeems to me to denote the conſequences of thoſe laws of nature to which volcanos owe their origin. The ſpecific gravity of the globe exceeds 3 or 4 times that of water, and conſequently its proportion of earth is greater than that of water; but at the creation the maſs of water as ſpecifically lighter, lay for the moſt part at the ſurface, until by the excavation of the bed of the ocean, and by evaporation, it made way for the appearance of dry land. Hence the interior regions of the globe, were never ſo overwhelmed with water, but volcanos might be formed within them, as they are at this day under the ſea. The flame of theſe fires being adapted to excite the ſenſation of light, ſufficiently authoriſed Moſes to call it by that name, and the period during which it exiſted by that of *Day*, in contradiſtinction to the period of darkneſs which preceded and ſucceeded it. Mr. *Giraud de Soulavie* has diſtinctly proved the exiſtence of theſe primæval volcanos, in various parts of his Natural Hiſtory of the *South* of *France*.

Alluvial mountains are evidently of poſterior formation, as they contain petrefactions and

and other veftiges of organic fubftances, they are always ftratified.

The principal granitic ridges are flanked by argillaceous, as thefe are by alluvial mountains.

Of the height of Mountains.

There is no circumftance relating to mountains, that excites the furprife, or interefts the curiofity of mankind to a greater degree than their height; hence many methods have been devifed to determine it. The trigonometrical is the moft antient, and in many cafes exact, but it is often imperfect, and in fome cafes impracticable; the barometrical alfo remained for a long time imperfect, until the celebrated Mr. *De Luc*, with indefatigable induftry, and uncommon fagacity, brought it to a degree of accuracy, fcarce to be expected. Some improvements have lately been made in it by Sir *George Shuckburgh*, and the calculation has been rendered ftill more fimple by Mr. *Magellan.*

In this method the elevation of mountains is determined by the different heights of 2 columns of mercury, one at the top and the other at the bottom of the mountain, the degree

gree of heat of each being equal, or reduced to an equality, and the common temperature of the atmoſphere being given. Two barometers are therefore uſed, and each has a thermometer annexed to it. The degree of heat to which both barometers are reduced, is 55° of Fahrenheit, yet if either of the barometers be at 30 inches, and the thermometer attached to it at 55, no reduction need be made in that barometer; but if either barometer be at 30, and the thermometer attached to it below 55°, we muſt add the expanſion the mercury would have by the heat of 55°, or if it be above 55° we muſt ſubtract the exceſs of expanſion it gains by that heat.* Now every degree of Fahrenheit produces an expanſion, of, 00304 of the barometrical inch, when the barometer is at 30, therefore when the thermometer is at n degrees below or above 55° we muſt add in the former, or ſubtract in the latter caſe, 0,00304 n to, or from the barometrical height. But if the mercury in the barometers ſtand above or below 30 inches, then let the correction be found as if the mercury were at 30, and let it be denoted by c, the correction ſought by x and the barometrical height h, then $\frac{hc}{30} = x$. The thermometers ſhould go alike, or if not, the difference ſhould be obſerved and ſubtracted.

* The fractions to be added or ſubtracted, are marked on a ſeparate ſcale, called the ſcale of correction.

The

The barometrical heights, of both barometers being thus corrected, the logarithm of the number of inches at which the mercury in the upper ſtands, is to be ſubſtracted from the logarithm of that of the lower; the difference between the 4 firſt decimal figures on the left gives *nearly* the number of fathoms, as that of the two laſt decimals does of the parts of a fathom between the upper and lower barometers, which being multiplied into 6, gives the number of feet and parts of a foot.

I ſaid *nearly*, for this height is not exact, except when the mean temperature of the atmoſphere is $31^{\circ},24$ of Fahrenheit.

The mean temperature of the atmoſphere is the arithmetical mean between the degrees, marked by two *detached* thermometers, one above, and the other below, both being held for about an hour in the ſhade.

When this medium is $31^{\circ},24$, the above method is juſt, and requires no further correction, but if the medium exceeds, or falls ſhort of $31^{\circ},24$ that difference muſt be found, ſuppoſe it $= d$.

The approximate height muſt now be corrected by multiplying it in feet, into the fraction 0,00243, let the product $= p$, then

pd

pd added to the approximate height, if the mean temperature be above 31°,24, or ſubſtracted from that height, if the mean temperature be below 31,24 gives the true height.

The following example will make the calculation more intelligible, the inſtruments on the top of the mountain are denoted by *A*, and thoſe at the bottom by *B*.

Observations.

Barometer A	- -	25,19 Inches.
Its attached thermometer		46°
Detached thermometer A		39,5
Barometer B at the ſame time		29,4
Attached thermometer	-	50
Detached ditto	- -	45°

Calculation.

Here the lower barometer ſtands below 30 inches, and its attached thermometer below 55° namely at 50. then $n=5$ and $,00304 \times 5 =,01520$ this would be the correction to be added if the barometer were at 30, but as it is at 29,4 then

$$\frac{b\,c}{30} = \frac{,29,4 \times ,01520}{30} = \frac{,44688}{30} =,01489 = x$$

which

which is to be added to 29,4 $\left.\begin{array}{r}29{,}4000\\+{,}0148\end{array}\right\}=$ 29,415 its corrected height

Again the upper barometer is at 25,19 inches, and its attached thermometer at 46 then $n=9$. and $c=,02736$ and $\frac{h\ c}{30}=\frac{25{,}19\times 02736}{30}$ $=,02297=x$ and $25{,}19+02297=25{,}21297$ or in round numbers 25,213 as its corrected height.

Now the logarithm of 29,415 is 1,468568, and the log. of 25,213 is 1,401624, whose

	4685,68
difference is - - -	4016,24
	669,44

The difference of the 4 first figures on the left, gives the number of fathoms, and is therefore separated by a comma from the last, which gives the decimal parts of a fathom, and 669,44, × 6=4016,664 feet, this is the approximate height.

The mean temperature is next to be found. The detached thermometer *A* was at 39,5, and the detached thermometer *B* at 45, now then

39,5

$39,5+45=84,5$ and $\frac{84,5}{2}=42,25$, which is therefore the mean temperature of the atmosphere; the difference between this and $31,24 = 11,01 = d$.

The fraction ,00243 is now to be multiplied into 4016,664, the product is 9,7604 which multiplied into $d=107,462$, and as the mean temperature is above 31,24. *pd* is to be added to the approximate height then $4016,66+107,46=4124,12$ feet, the true corrected height.

Some of the most remarkable mountains, whose heights have been taken with tolerable accuracy are,

In America.

	English feet above the level of the sea.
Chimboraço - - -	20575,8 or 3,89 miles.
El Coraçon - - -	15783
The town of Quito - - -	9242

In Africa.

Teneriffe - - -	11022	De Borda 13 *Roz.*
Pico Ruivo in Madeira - - -	5141	*Phil. trans.* 1765.

In

In Europe.

Mont Blanc, higheſt of the Alps	15672	Sir G. Shuckburgh *Phil. tr.* 1777.
Veſuvius in 1776 - -	3938	Sauſſure.
Ætna - - - -	10954	
Canigou, one of the Pyrenees	9214	
St. Bartelemi in pays de Foix	7565	
Mont d'Or in Auvergne - -	6696	
Puy de Dome - - -	5221	
Hecla - - - -	5000	Von Troil.

The height of the Aſiatic mountains has never been accurately determined. Mr. *Bergman* remarks, that the ſphericity of the earth is no more altered by the height of the higheſt mountain, than that of a globe of 2 feet in diameter, would be by an elevation of the ſize of a grain of ſand.

The line of congelation in ſummer, under the Æquator, is at the height of 15400 feet; at the entrance of the temperate zone, 13428; on *Teneriffe*, in latitude 28, at about 1000; in *Auvergne*, in latitude 45, at 6740 nearly; with us, in latitude 52, it is probably at 5740. The greateſt height hitherto aſcended, is 15783 feet; in *Peru*, vegetation ceaſes at the height of 14697 feet, and on the *Alps*, at 9585, Mr. *Sauſſure* found the air leſs pure at 3834 feet; Mr. *D'Arcet* obſerved, that on the

the *Pic de midi* (one of the Pyrenees, lower than *Conigou)* ſalt of tartar remained dry for an hour and a half, though it immediately moiſtened at the bottom of the mountain. The vapor of marine acid was alſo inviſible on the ſummit. The electric and magnetic powers were as ſtrong as on the plain. 8 *Roz.* 403.

Of the Structure of Mountains.

Mountains conſidered as to their ſtructure, are divided into *intire*, *ſtratified*, and *confuſed.*

Intire mountains are formed of huge maſſes of ſtone, without any regular fiſſure, and moſtly homogenous; they conſiſt chiefly of granite, ſometimes of gneiſs, ſhiſtus, flagſtone, ſandſtone, limeſtone, gypſum, porphyry, ſerpentine, or trapp. Some in *Sweden* and *Norway* conſiſt of iron.

Stratified mountains are thoſe whoſe maſs is regularly divided by joints or fiſſures; theſe ſtrata are conſidered in relation to the angle which their fiſſures make with the horizon and meridian, with reſpect to the former they are called horizontal, riſing, or dipping. With regard to the latter, they are ſaid to run to this or that point ſo many degrees;

they are moſt commonly parallel to eachother, and riſe or fall with the mountain.

The ſtrata of which mountains conſiſt, are either *homogeneous* or *heterogeneous*.

Homogenous ſtratified mountains conſiſt chiefly of ſtones of the argillaceous genus, as ſhiſti, hornſtones, flagſtones, or of the fiſſile compound ſpecies of the ſiliceous genus, as gneiſs, and metallic rock, or of both, the one behind the other. Sometimes of primæval limeſtone, that is, limeſtone of a granular or ſcaly texture, in which no animal veſtiges appear. This limeſtone repoſes on the argillaceous or ſiliceous ſtrata; ſometimes the argillaceous are covered with maſſes of granite, and ſometimes with lava.

Theſe mountains, as already obſerved, are the chief ſeat of metallic ores, particularly thoſe of gneiſs, metallic rock, and hornſtone. When they are covered with limeſtone, the ore is generally between the limeſtone and the argillaceous ſtones. Theſe ores run in veins and not in ſtrata. The calcareous rarely contain any ore, when they do, it is either iron, copper, lead, or Mercury. Petrefac-
tions

tions are found upon, but not in theſe mountains.

Heterogenous, or compound ſtratified mountains *, conſiſt of alternate ſtrata of various ſpecies of ſtones, earths or ſands either of the calcareous or argillaceous genus, or both, or metallic ores, and ſometimes lava, as toadſtone, &c. The lime-ſtone is always of the laminar, and not of the granular or ſcaly kind, and when it contains any ore, this is placed between its laminæ; it is very ſeldom that ſtones of the ſiliceous genus form any ſtratum in theſe mountains, except lavas; but the ſtrata are frequently interrupted by ſiliceous maſſes; ſuch as jaſper, porphyry, granite, &c. theſe may be called *ſtops* †. Coal, bitumen, petrifications and organic impreſſions, are found in theſe mountains; alſo ſalts, calamine, gold in the ſandy ſtrata, iron in intire ſtrata or neſtways, copper in the ſtrata, lead ore, ſingly or mixed with copper, (it ſometimes ſhoots through the ſtrata in ſmall veins,) cobalt ore in the ſtops, pyrites every where; it ſometimes conſtitutes whole ſtrata; the matrixes of theſe ores are chiefly of the calcareous or barytic genera, rarely quartz, and never mica.

* *Flotzgeburge.*

† *Klancken, kamme, Rucken Weckſel.* I am not acquainted with the correſpondent *Engliſh* technical terms.

There are other mountains analogous to theſe, which yet cannot properly be called ſtratified, as they conſiſt only of three immenſe maſſes; the loweſt granite, the middle of the argillaceous genus, and the uppermoſt of lime-ſtone. When they are metalliferous, as they generally are, the metallic ores are found in the argillaceous part, or between it and the calcareous; theſe ores form veins or bellies, and not ſtrata; theſe may be called *triplicate* mountains.

Confuſed mountains; that is, of a confuſed or promiſcuous ſtructure, conſiſt of ſtones of all ſorts heaped together without any order; their interſtices are filled with ſand, clay and mica; they ſcarce ever contain any ore.

Of Volcanos.

Volcanos, or burning mountains, are peculiar to no climate, and have been obſerved in every quarter of the globe: they have no neceſſary or regular connection with other mountains, but they ſeem to have ſome with the ſea, for they are generally placed in its neighbourhood. It is true that antient extinguiſhed volcanos have lately been diſcovered in the inland parts of moſt countries; but this is one of the many proofs that the ſea at ſome remote period covered thoſe countries.

tries. Sub-marine volcanos have often been obſerved even in our own times.

Theſe mountains are of all heights, ſome ſo low as 450 feet, as that in *Tanna**, but they generally form lofty ſpires, internally ſhaped like an inverted cone placed on a broader baſis. This cone is called the crater of the volcano, as through it the lava generally paſſes, though ſometimes it burſts from the ſides, and even from the bottom of the mountain; ſometimes the crater falls in and is effaced; ſometimes in extinguiſhed volcanos it is filled with water, and forms thoſe lakes that are obſerved on the ſummit of ſome mountains.

Both the crater and baſis of many volcanic mountains conſiſt of lava either intire or decompoſed, nearly as low as the level of the ſea, but they finally reſt either upon granite, as the volcanos of *Peru*, or on ſhiſtus, as the extinguiſhed volcanos of *Heſſe* and *Bohemia*, or on lime-ſtone, as thoſe of *Sileſia*, the *Vicentine Alps*, and *Veſuvius*. The decompoſed and undecompoſed lavas form irregular ſtrata that are never parallel to each other. No ore is found in theſe mountains, except iron, of which lava contains from 20 to 25 per cent.

* *Foſter*, 143.

and ſome detached fragments of copper, antimonial and arſenical ores.

If we conſider the immenſe quantity of matter thrown up at different periods by volcanic mountains, without leſſening their apparent bulk *, we muſt conclude the ſeat of theſe fires to be ſeveral miles, perhaps hundreds of miles, below the level of the ſea; and as iron makes from $\frac{1}{5}$ to $\frac{1}{4}$ of all theſe ejections, we may infer that the interior parts of the earth conſiſt chiefly of this metal, its ores, or ſtones that contain it, whoſe greater or leſſer dephlogiſtication in different parts may be the cauſe of the variation of magnetic direction.

The origin of theſe fires is not eaſily accounted for. It is well known that martial pyrites, being moiſtened, will acquire heat; but that this heat ſhould burſt into actual flame, the concourſe of open air is abſolutely requiſite; however, if we ſuppoſe the heated pyrites to have been in contact with black wad and petrol, we may ſuppoſe the flame to ariſe, as we ſee it produced by art from the deſiccation of that ſubſtance, and its mixture with the mineral oil. That ore when heated affords dephlogiſticated air,

* Mr. *Gerhard* computes that *Veſuvius* has ejected from the year 79 to the year 1583, 309658161 cubic feet. 2 *Mineral. Geſch.* §. 87.

of

of which a very fmall quantity is fufficient to produce flame: this flame once produced, may be fupported by dephlogifticated air from other ores, which Dr. *Prieftly* has fhewn to afford it, and the phlogifton may be fupplied by pyrites, bituminous fhiftus, bitumen and coal; marl, fhiftus, horn-ftone, fhoerl, with a further addition of iron from the pyrites, are the true fources of the melted matter or lava. The explofion and eruption of this melted matter proceeds, in all probability, from the accefs of a large quantity of water, which either enters through fome crack in the bottom of the fea, or from fources in the earth; if the mafs of water fo admitted be fufficiently great, it will extinguifh the fubterraneous fire; if not, it will fuddenly be converted into vapour, whofe elaftic force is known to be feveral thoufand times greater than that of gunpowder; if the fuperincumbent weight be too great, it may caufe earthquakes, but will propel the melted matter laterally towards the mouth of the volcano, where, meeting with leaft refiftance, it will expel it, together with all the unmelted ftony maffes it meets in its paffage. It is eafy to conceive that before the denfe melted matter is ejected, the dilated air of the volcano will firft be forced out, and carry with it the afhes and loofer ftones adhering to the fides and crater of the volcano, as has been

 obferved,

obſerved, and elegantly deſcribed by our modern *Pliny* Sir *William Hamilton.*

The ſubſtances ejected by volcanos are, phlogiſticated, fixed, and inflammable air, water, aſhes, pumiceſtones, ſtones that have undergone no fuſion, and lava.

The water proceeds partly from that contained in the volcano, partly from the condenſed vapors, and partly perhaps from the intimate union of the phlogiſton and dephlogiſticated air; an union which ſome late experiments ſhew to be productive of water in certain circumſtances. Part of the aſhes is plentifully moiſtened with this water, and forms *tufa traaſs*, &c.

Stones of all ſorts and ſizes, even of 10 feet in diameter, are projected by volcanos, and ſometimes to great diſtances: hence probably thoſe ſolitary maſſes of granite, which are ſometimes met with in lime-ſtone countries.

Lavas, in their paſſage through the volcano and its caverns, and during their flowing, neceſſarily involve various ſorts of ſtone, which are not therefore products of fire, though found in lava; ſuch as quartz, ſpar, ſhoerl, &c. and thus various porphyries and pudding-

pudding-ſtones are found, which have lava for their ground.

Baſaltes, and in many inſtances ſhoerl, ſeem to me to owe their origin both to fire and water: they ſeem to have been at firſt a lava, but this lava, while in a liquid ſtate being immerſed in water, was ſo diffuſed or diſſolved in it with the aſſiſtance of heat, as to cryſtalize when cold, or coaleſce into regular forms. That baſaltes is not the reſult of mere fuſion appears by a compariſon of its form with its texture; its form, it being cryſtalized, ſhould be the effect of a thin fuſion, but in that caſe its texture ſhould be glaſſy; whereas it is merely earthy and devoid of cavities. Hence we may underſtand how it comes to paſs that lava perfectly vitrified, and even water, are ſometimes found incloſed in baſaltes. *Mon. Mineral.* 511. *Von Troil*, 285.

The immenſe maſſes of lava ejected by volcanos, preſenting but a relatively ſmall ſurface to the atmoſphere, are many years in cooling, and many hundreds of years are required for their decompoſition; this decompoſition is quicker or ſlower as they have been more or leſs perfectly melted. According to the obſervations of Sir *William Hamilton*, the lava of *Veſuvius* forms one or two feet of mould in 1000 years; this bed of mould being

being afterwards covered with fresh lava, and this, after mouldering by that of still latter eruptions, affords some ground for calculating the age of the volcano at least within certain limits.

The beds of lava are deepest and narrowest in the proximity of the crater, and broader and shallower as they are more distant, unless some valley intervenes; pumicestone and ashes lie still more distant. From these observations extinguished volcanos are traced. Many excellent investigations of this sort may be seen in Mr. *Soulavie*'s history of the south of *France*.

Basaltic mountains (common in *Sweden*) seem to owe their origin to sub-marine volcanos.

Petrifications.

The most remarkable observations relative to petrifactions are,

1st. That those of shells are found on or near the surface of the earth; those of fish deeper, and those of wood deepest. Shells in *specie* are found in immense quantities at considerable depths.

2dly. That those organic substances that resist

ſiſt putrefaction moſt are frequently found petrified; ſuch as ſhells and the harder ſpecies of woods: on the contrary, thoſe that are apteſt to putrefy are rarely found petrified, as fiſh, and the ſofter parts of animals, &c.

3dly. That they are moſt commonly found in ſtrata of marl, chalk, lime-ſtone or clay, ſeldom in ſand-ſtone, ſtill more rarely in gypſum, but never in gneiſs, granite, baſaltes or ſhoerl; but they ſometimes occur among pyrites, and ores of iron, copper and ſilver, and almoſt always conſiſt of that ſpecies of earth, ſtone, or other mineral that ſurrounds them, ſometimes of ſilex, agate, or carnelian.

4thly. That they are found in climates where their originals could not have exiſted.

5thly. That thoſe found in ſlate or clay are compreſſed and flattened.

Of Metallic Ores.

Iron ore is the only one that forms intire mountains, all other ores form but an inconſiderable part of the mountain in which they are found.

Ores either run parallel to the ſtony ſtrata, or

or run acroſs them in all directions; theſe laſt are called *veins*.

The courſe of veins, with relation to the meridian, is called their *direction*, and with relation to the horizon is called their *inclination*.

Their direction, in the language of miners, is denoted by *hours*; the horizontal circle being divided into twice 12 hours, 12 from ſouth to north, and 12 from north to ſouth: eaſt and weſt directions are therefore denoted by 6 o'clock.

Inconſiderable veins that diverge from the principal are called *ſlips*; conſiderable maſſes of ore that have no great length are called *bellies* or *ſtock-works*; ſo are alſo accumulated veins or thick bodies of ore formed by the junction of ſeveral veins.

The ſtones which fill the cavities that form the veins are called the matrix (gang) of the ore; the rocks that lie over the veins are called the *roof*; thoſe that lie under them the *floor*, and by ſome the *hading*; the matrix is almoſt always a finer ſpecies of ſtone than the ſurrounding rocks, though of the ſame genus; even the rocks themſelves are finer grained as they approach the vein.

There

There is no matri arly appropriated to any metal; it h been remarked, that tin is generall among ftones of the filiceous genus, ad very frequently among thofe of the areous.

There is no certain fign from which the exiftence of an ore in any mountain may be inferred, except the veftiges of it in the beds of torrents or mineral waters, and the ftructure of the mountain itfelf, of which enough has been already faid.

Of Hot Springs.

Mr. *Tiffington* has remarked, that waters flowing through a blue marl filled with nodules of pyrites are warm; Mr. *Guettard* has alfo obferved, that all the hot mineral fprings of *France* flow from fhiftus: hence there is no occafion to derive their heat from any fubterraneous volcano.

TABLE

T[illegible] I.

The Quantity of M[illegible] Reguline State afforded by 100 G[illegible]f different Metallic Calces, and to wh[illegible] [c]onsequently they are respectively equivalent.

100 Grains - - - - -	Grains.
Brown calx of iron afford of regulus - - -	from 79 to 89 grs.
Red ditto - - -	from 71,4 to 78
Brown calx of copper	from 84 to 86,5
Minium - - - - -	89
Calx of tin - - - -	96
Precipitate per fe - -	92
Flowers of zinc - -	85,5
Calx of bifmuth - -	98
Grey calx of antimony	96
White calx of manganefe	54

Hence the quantity of calx, which 100 parts of any of thefe metals would afford, is eafily found; thus 100 gr. of lead would afford 113 of minium for ∺ 89. 100 : : 100 113.

TABLE

TABLE II.

Of the Weight and Colour of Metallic and Earthy Precip
with some Alterations and Additions from the 2d vol. *of* M

100 *Grains.*	*Precipitated by*	*Weight.*	*Colour.*
Gold.	Aerated Min. Alkali	106 Gr.	Yellowish.
	Caustic Ditto - -	110	Darker, retains more acid than the for
	Prussian - - - -	- -	Yellowish or bluish from Iron, not to
Silver. In Nitrous Acid	Aerated, &c. - -	129	White.
	Caustic - - - -	112	White.
	Prussian - - -	145	Brick colour, or if dilute, flesh colour.
	Marine Acid - -	133	White cloud or clots.
Copper. Nitrous Acid	Aerated - - -	194	Bluish green.
	Caustic - - - -	158	Greyish brown.
	Prussian - - -	530	Dark red.
Iron. Vitriolic or Marine Acid	Aerated - - -	225	Greenish brown, and soon after yellowish.
	Caustic - - - -	170	Darker brown.
	Prussian - - -	590	Blue.

TABLE II. *Continued.*

100 *Grains.*	*Precipitated by*	*Weigh.*	*Colour.*
TIN. Aqua Regia, or Marine Acid	Aerated - - -	131	White.
	Cauſtic - - -	130	White.
	Pruſſian - - -	250	Dark green, and ſoon after blue.
LEAD. Nitrous Acid	Aerated - - -	132	White.
	Cauſtic - - -	116	White.
	Pruſſian - - -		Greeniſh yellow, and after ſome time whit[illegible]
	Vitriolic Acid -	143	Or if well waſhed, 137. White grains
MERCURY. Nitrous Acid	Aerated - - -	110	Brick colour.
	Cauſtic - - -	104	Yellower.
	Pruſſian - - -		White and yellow, with ſpots of green.
	Vitriolic Acid - -	130	Or 119 if waſhed. White.
ZINC. Nitrous Acid	Aerated - - -	193	Dull white.
	Cauſtic - - - -	161	Dull white.
	Pruſſian - - - -	495	Reddiſh yellow, and after ſometime [illegible]
Regulus of Antimony.	Aerated - - -	140	Dull white.
	Cauſtic - - -	138	Dull white.
	Pruſſian - - - -	138	Blue, eaſily re-diſſolved by exceſs,

BISMUTH. Nitrous Acid	Aerated - - - -	130	White. (Aerated and Caustic)
	Caustic - - - -	125	
	Prussian - - - -	180	Reddish yellow.
	Water - - - -	113	White.
NICKEL. Nitrous Acid	Aerated - - -	135	Whitish green. (Aerated and Caustic)
	Caustic - - - -	128	
	Prussian - - - -	250	Dirty reddish yellow, or red and green.
COBALT. Nitrous Acid	Aerated Alkali -	160	Greenish pale red. (Aerated Alkali and Caustic)
	Caustic - - - -	140	
	Prussian - - - -	142	Blue, greyer than that of iron.
ARSENIC. Marine Acid, or Aqua Regia	Aerated - - - -		White, imperfect. (Aerated and Caustic)
	Caustic - - - -		
	Prussian - - - -	180	Green and yellow mixed.
MANGANESE. Nitrous Acid	Aerated - - -	180	Brownish red when dephlogd. or white if phlogm. (Aerated and Caustic)
	Caustic - - - -	168	
	Prussian - - - -	150	Dirty bluish grey, and after some time, brownish grey.
EARTHS.			
Barytes	Prussian - - - (for Barytes, Nitrous Acid, Marine, Acetous)	150	Reddish white.
Nitrous Acid			Greenish white.
Marine			Yellowish and greenish white.
Acetous			

D d

TABLE II. *Continued.*

100 *Grains.*	*Precipitated by*	*Weigh.*	*Colour.*
Pure Lime	Aerated Alkali -	181,8	
	Caustic - - -	130	
Magnesia	Aerated - - -	222	
	Caustic - - - -	118	
	Caustic Vol. - -	110	

100 Grains regulus of antimony, dephlogisticated by nitrous acid, weigh 138

100 Grains tin, dephlogisticated by nitrous acid, weigh 140 grains

REMARKS.

The precipitates are generally supposed to be well washed in di[illegible] and dried in a heat of 212 of Fahrenheit, to which they are exposed for

The precipitate of bismuth by *Prussian* alkali, is re-dissoluble acid. That of lead is not.

The quantity of *Prussian* alkali necessary to precipitate barytes [illegible] acid, is to that necessary to precipitate iron from the marine, as 1

 9

… Earths and Stones.

… .

	Calca…	[illegible]	Silex.	Magn.	Wat.	Iron.
…s Spar	55	— —	— —	—	11	— [a]
[illegible] - - -	32	— —	— —	—	38	— [b]
Fluor - - - -	57	— —	— —	—	—	— [c]
Tungſten - - -	50	— —	— —	—	—	— [d]
Compound Spar	60	— —	— —	35	—	5 [e]
Cruetzenwald Stone	75	— —	— —	12	—	3 [f]
Calcareous Marle	50 to 75	20 to 30	20 to 30	—	—	— [g]
Margodes - - -	50	32	15	—	—	2
Stellated Spar -	66	— —	30	—	—	3
Calcareous Grit or Sand Stone	50	— —	— —	—	—	— [h]
Swine Stone -	95	— —	— —	—	—	— [i]
Pyritaceous Limeſt.	75	14	— —	—	—	4 [k]
Martial Tungſten	— —	— —	— —	—	—	50 [l]

a And 34 Fixed Air. *b* And 30 Vitriolic Acid. *c* 43 Acid and Water. *d* 50 Acid and Iron, *e* Both Earths mild. *f* Ditto. *g* And Water. *h* Or more. Remainder, Silex, Argill, and Iron. *i* And Petrol, remainder, Argill and Iron. *k* And 7 Quartz and Sulphur, that is, 25 Pyrites. *l* By the dry way only 30, and 50 Tungſten.

Barytic Genus.

100 Parts.

Mild Barytes — 78 Earth, 20 Fixed Air, 2 Baroſelenite.
Baroſelenite — 84 Earth, 13 Vitriolic Acid, and 3 Water.
Hepatic Stone — 33 Baroſelenite, 33 Silex, 22 Allum, 7 Gypſum, 5 Petrol.

Muriatic

T

100 Parts.

Mild magnesia -	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Keffekil - - - -	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Steatites - - -	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Argillaceous ſteatites	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Chalk of Briançon - -	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Soap Rock - - - -	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Aſbeſtós - - - -	63	11	20	4	[illegible]	—
Martial abeſtos - - -	62	12	13,7	1,7	—	[illegible]
Suber montanum - -	59	11	24	2,4	—	[illegible]
Amianthus - - - -	64	6,9	18,6	3,3	—	1,2 §
Serpentine - - -	45	—	23	18	12	3
Talc Muſcovy - - -	50	—	45	5	—	—

Talc Venetian - - - a larger portion of argill and ſmaller of magneſia.

Note, The magneſia and calcareous earths are in a mild ſtate in all the above ſtones.

* At a medium and 30 fixed air. † And 2 of talc. ‡ At a medium. ‖ At a medium. § And 6 barytes.

Argillaceous Genus.

	Silex.	Argill	Calcareous	Magneſia.	Iron.	Water.
Pure clay dry - -	63	37*	——	——	—	—
Argillaceous marl dry	46	27	25 †	——	—	—
Fuller's earth -	53	18	5	3	4	17‡
Pouzzolana - -	57	20	6	——	20	—
Tripoli - - - -	90	7	——	——	3	—
Pure mica - - -	38	28	——	20	14 ‖	—
Martial mica -	34,5	25,5	——	18	22	—
Roof ſlate or ſhiſtus	46	26	4 mild	8 mild	14	—
Flagſt. or argill. ſhiſt.	36	56	——	——	4	—
Horn-ſtone - -	37	22	2	16	23	—
Killas - - -	60	25	——	9	6	—
Toadſtone - - -	63	14	7	——	16	—
Zeolyte - - -	60	20	8	——	—	12 §
Pitch-ſtone - -	65	16	——	——	5	14 ¶

Gronſten - - - Horn-ſtone and mica, or horn-ſtone and ſhorl.

Stellſten - - Mica, quartz and argill.

Binda - - Horn-ſtone, mica, ſhorl, quartz, and pyrites.

Growan - - Argill, mica and quartz.

* At a medium when perfectly dry, 63 ſiliceous. † Mild at a medium. ‡ And marine acid at a medium. ‖ White calx of iron. § At a medium. ¶ And air.

[illegible]ued.

[illegible]	[illegible]	[illegible]l	Calcar.	Magn.	[illegible]
[illegible]	[illegible]	[illegible]	1	—	[illegible]
[illegible]	[illegible]	8	2	—	[illegible]
[illegible]	[illegible]	22	6	—	—
[illegible]	[illegible]	20	—	—	5
[illegible]	[illegible]	16	—	—	—
[illegible]	[illegible]	40	mild 9	—	10
[illegible] - - -	[illegible]	46	ditto 8	—	6
[illegible]th - - - -	25	40	dit. 20	—	13
Emerald - - - -	24	60	8	—	6
Sapphire - - -	35	58	5	—	2
Chryſopraſium - - -	95	—	1,7	1,2	0,4 [a]
Lapis lazuli - - - -	—	—	—	—	— [b]
Feltſpar - - - - -	67	14	—	8	— [c]
Veſuvian garnet - -	55	39	6	—	—
Garnet - - -	48	30	12	—	10
Martial Garnet - -	43,6	27,6	10	—	19
Shoerl tranſparent - -	48	40	5	1	5
Shoerl Black - - - -	58	27	5	1	5
Bar ſhoerl - - -	61,6	6,6	21,6	5	1,6 [d]
Tourmaline - - -	37	45	13	—	5 [e]
Baſaltes - - -	52	15	8	2	25
Rowley ragg - - -	47,5	32,5	—	—	20
Comp. and cellular lava	47	30	5	—	18
Vitreous ditto - - -	49	35	4	—	12
Another from Lipari -	69	22	—	—	9
Black agate of Iceland nearly as the above	—	—	—	—	—
Pumice ſtone - - -	84 or 90	—	—	6 to 15	— [f]
Martial muriatic ſpar -	50	—	—	30 mild	20 [g]
Turkey ſtone - - -	70	5	mild 25	—	— [h]
Ragg ſtone - - - -	70	5	dit. 20	—	5 [i]
Siliceous grit with calcareous cement -	62,5	—	d° 37,5	—	—
Siliceous ditto with argillaceous cement -	77	20	—	—	3 [k]
Ditto with ferruginous cement - - -	80	5	—	—	15 [l]

a 0,6 copper, and ſparry acid. *b* 80 martial fluor, 20 gypſum, as I believe. *c* 11 Ponderous. *d* 5 water. *e* At a medium. *f* Remainder calcareous. *g* As I believe. *h* As I believe. *i* As I believe. *k* As I believe. *l* As I believe.

10

T

...n
...itello
...apakivi
Granitone
Murksten
Norka } Q...

Porphyry	Ja... lava, shoer... quartz, felt spar, shoerl, ... serpentine in a crystaline fo...
Pudding stone	Jasper, chert, siliceous grit, or lava, containing pebbles of an oval form
Siliceous breccias	The same ground and contents, but in angular forms.
Gneiss	Quartz, mica, steatites. Quartz, mica, serpentine. Quartz, mica, shoerl, steatites, or soap rock. Quartz, felt spar, mica, serpentine.
Amygdaloides	Jasper, or chert, containing spar or serpentine.
Metallic rock of Born	Quartz, clay and steatites, and felt spar sometimes.
Variolite	Serpentine, containing various stones.

Proportion of Ingredients in Natural Salts.

	Acids	Alka.	Earth	Water	
Tartar vitriolate	31	63	—	6	
Glauber's salt	14	22	—	64	
Vitriolic ammon.	42	40	—	18	
Epsom	24	—	19	57	
Alum	24	—	18	58	
Vitriol of iron	20	—	—	55	25 iron.
Ditto of copper	30	—	—	43	27 copper.
Ditto of zinc	22	—	—	58	20 zinc.
Nitre	30	63	—	7	
Cubic nitre	29	50	—	21	
Nitrous ammon.	46	40	—	14	
Nitrous selenite	33	—	32	35	
Ditto Epsom	36	—	27	37	
Salt of Silvius	30	63	—	7	
Common salt	33	50	—	17	
Sal. ammoniac	52	40	—	8	
Marine selenite	42	—	38	20	
Borax purified	34	17	—	47	

ches of it unite[d]
[o]f sulphur.
[...]s of phlogiston.

Proportion of Ingredients in Metallic Ores.

100 Parts. *Gold.*

Ore of *Adelfors* or *Norway*—99,59 martial pyrites 0,41 gold.

—— of *Salsburg* in *Tyrole*—$\frac{948}{1000}$ arsenical pyrites, and, 052 of gold.

—— of *Nagaya*—99 pyrites, galena and silver, 0,83 of gold.

Gold sand of *Africa*—0,22 at most.

---

100 Parts. *Silver.*

Vitreous ore—25 sulphur, and 75 of silver.

Slightly arsenicated at *Quadanal-canal*—10 arsenic, and 90 of silver.

—— superarsenicated at ditto—ditto from 4 to 6 ozs. of silver per quintal.

Red ore—31 realgar, 8 sulphur, and 60 silver generally.

Black ore solid—40 sulphur, arsenic, and pyrites, and 60 silver.

Black

ore loose-
silver at m
genico-martial c
and arsenic, an
White ore—from
copper, arsenic, a an iro
30 of silver.

Grey ore—from 12 to 24 of copper, from
to 12 of silver, and the remainder sulphur, arsenic, and a little iron.

Brown ore—mostly copper, sulphur, arsenic, a little regulus of antimony and iron, and from 1 to 5 per cent. of silver.

Plumose ore—pyrites, arsenic, antimony, and about 1 per cent. of silver.

Cobaltic ore—sulphur, arsenic, cobalt, iron, and from 40 to 50 per cent. of silver.

Vitriolic and *marine silver*—about 70 of silver.

---

100 Parts. *Copper.*

Red calx of copper—26 fixed air, 1 water, 73 copper.

Brownish red—pyrites, and from 20 to 50 of copper.

Malachite—29 aerial acid and water, and 71 of copper.

Mountain green—22 aerial acid, 6 water, and 72 of copper.

Mountain blue—29 aerial acid, 2 water, and 69 of copper.

Vitreous

ſulphur,

from 40 to 6

lphur.

ites, ſulphur, and
copper.

oppe arſenic, pyrites, from 35
o 60 copper, and a little ſilver.

Blendoſe copper ore—pyrites, pſeudo galena, from 18 to 30 copper.

Shiſtoſe copper ore—ſchiſtus, ſulphur, from 6 to 10 of copper.

---

100 Parts. *Iron.*

Steel ore—from 60 to 80 iron.

Black eiſen rahm—74 plumbago, 26 iron.

Sparry iron ore—38 calcareous earth, 24 mangameſe, and 38 iron.

Flos ferri—65 calcareous earth, and 35 calx of iron.

Magnetic ſand of *Virginia*—about 50 of iron.

Hæmatites—from 40 to 80 of iron.

Grey iron ore—ſiderite, and from 40 to 66 of iron.

Highland argillaceous ore—from 30 to 66 of iron.

Ditto *ſwampy*—ſiderite, and 36 of iron.

Siliceous ore—25 to 30 of iron.

100

12

o Parts.

Black tin ore—80 ti

Red ditto—more of

Sulphurated tin—40 p ... n, copper, the remainder tin.

---

100 Parts. *Lead.*

White lead ore—a little iron, argill or calcareous earth, 80 to 90 of tin.

Red ditto—more iron, argill, 80 or 90 of lead.

Green ditto—ſtill more iron, ſeldom copper.

Bluiſh ditto—a little copper.

Vitriol of ditto—about 70 of lead.

Galena—from 15 to 25 of ſulphur, from 0,01 to 1,5 or 2 of ſilver, from 60 to 85 of lead, beſides quartz and iron.

Antimonial lead ore—antimony, from 0,08 to 0,16 ſilver, and from 40 to 50 of lead.

Pyritous lead ore——pyrites, 18 to 20 of lead.

Red lead ſpar—realgar, a little ſilver, and 43 of lead.

,

-About 70

2ó Sulphur, and 8o mercury.

Pyritous ore of mercury—Cobalt, arsenic, pyrites, 1 of mercury.

---

100 Parts. *Zinc.*

Vitreous Ore, Zinc, Spar—28 Aerial acid, 6 water, 1 iron, and 65 calx of zinc.

Tutanego—Iron, argill, and from 60 to 90 of zinc.

Calamine—Iron, clay, rarely calcareous earth or lead, 30 to 84 calx of ditto.

Zeolytic ore—Quartz, water, and about 36 calx of zinc.

Blende, psedogalena blue—8 iron, 4 copper, 26 sulphur, 4 water, 6 silex, and 52 zinc.

Ditto black—1 Arsenic, 9 iron, 6 lead, 29 sulphur, 6 water, 4 silex, and 45 zinc.

Ditto red—5 Iron, 17 sulphur, 5 water, 5 argill, 24 quartz, and 44 zinc.

Ditto, phosphoric—5 Iron, 20 sulphur, 4 sparry acid, 6 water, 1 silex, and 64 zinc.

Ditto grey—Galena, petrol, sulphur, 24 zinc.

100

13

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ate
ilver or

---

100 Parts *Regulus of Arsenic.*

Orpiment—10 Sulphur, and 90 arsenic.
Realgar—16 Sulphur, and 84 arsenic.

---

100 Parts. *Manganese.*

Sparry iron ore—50 Calcareous earth, 22 iron, and 28 calx of manganese.

---

100 Parts.
Molybdena—45 Acid, 55 sulphur.

FINIS.

no a[illegible]

[illegible] the ores whi[illegible] no names, but [illegible]ously descriptive.

3. The n[illegible]es of all compounds and super-compounds of earths and stones, and of all ores which are not obviously descriptive, so as to point out at first sight, in what part of the book, within a leaf or two, they may be sought, are inserted.
4. All synonimes are inserted.
5. In many instances, the name of a substance is inserted in two places, such as, words of which " Stone " and " Stein " are a part; so also are the vitriolic salts, and some among the German and Swedish appellations.
6. In general, references to another part of the Index, are avoided.

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